Case Studies in Applied Psychophysiology

Neurofeedback and Biofeedback Treatments for Advances in Human Performance

W. Alex Edmonds
and Gershon Tenenbaum

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Preface

W. Alex Edmonds and Gershon Tenenbaum

To our knowledge there are no published texts, books, or manuals that include case-studies which aim at enhancing human performance in nonclinical populations utilizing biofeedback (BFB) and neurofeedback (NFB) techniques. Consequently there is a strong need for students, practitioners, and researchers working with BFB and NFB to share and learn information through reviewing case-study analysis of other's practical experiences applying psychophysiological interventions. Many practitioners and researchers utilize BFB and NFB applying psychophysiological interventions to individuals with the goal of optimizing performance in a variety of domains such as music, dance, athletics, and exercise. However, most of the work, experiences, and lessons learned from these applications are not prepared, published, and presented to the population of interest.

The field of BFB and NFB is growing steadily, and the awareness of its effectiveness is becoming more widely accepted. Organizations such as the Association of Applied Psychophysiology and Biofeedback (AAPB), and the Biofeedback Certification International Alliance (BCIA) are actively supporting interest in the field by training, publishing research, holding annual conferences, conducting regional training, and providing professional development and certification programs. In addition, BFB and NFB equipment is becoming more affordable and user friendly. The affordability and the improvements of the software interfaces enhances the efficiency of its application in the field and lab by allowing practitioners, researchers, and students more access to these applications. Consequently, we developed this book detailing relevant, unique, and interesting case studies of individuals from nonclinical populations across various domains (e.g. sport, performing arts, and exercise) aimed at improving task-specific performance indices and written by practitioners and researchers in the field.

Purpose

As we stated above, there is no book currently on the market that details case-study analysis and written by professional practitioners on the topic of psychophysiological interventions in sport, performing arts, and exercise. The purpose of this book is to present previously unpublished case-study examples written by practitioners who utilized BFB or NFB as a tool to enhance performance with athletes or performing artists. Although the focus of the book is on nonclinical or non-medically related case studies, we do include two such cases of NFB utilized for individuals suffering from traumatic brain injuries. The steps of the case studies presented have been systemically recorded and presented in a way that allows for the reader to glean from the specific experience conveyed by the author. However, the specifics of the case detail are unique to the author's perspective and each protocol and procedures implemented vary from case to case. That is, the overarching goal of this book is to detail the idiosyncratic techniques and procedures seasoned practitioners utilize when applying BFB and NFB techniques with clientele interested in performance-related gains.

BFB and NFB are sophisticated tools, but very effective ones; consequently, understanding the applications of such tools can be complex, hence the reason why a BFB and NFB machine is not present in every psychologist's office. Outside of dealing with the high cost of complete BFB and NFB systems, a practitioner must combine his or her understanding of (a) hardware, (b) software, (c) physiology, (d) psychology, and (e) psychophysiology before successfully utilizing BFB/NFB as a tool embedded within an intervention.

Theoretically, and generally speaking, the effectiveness of BFB/NFB can be grounded in theoretical frameworks, such as the individual-response stereotypy, stimulus-response specificity, and the intake-rejection hypothesis. However, one must go beyond the physiological-response systems approach and understand that the true utility of BFB/NFB rests with the practitioner's ability to understand and integrate the physiological frameworks and the associated psychological theories. Traditional and long-standing theories such as the feedforward processes model, and operant and classical conditioning models of learning undergird and make the principle objective of BFB/NFB possible – that is, to improve self-awareness and self-regulatory skills. The interplay between the two is illustrated in Figure 0.1.

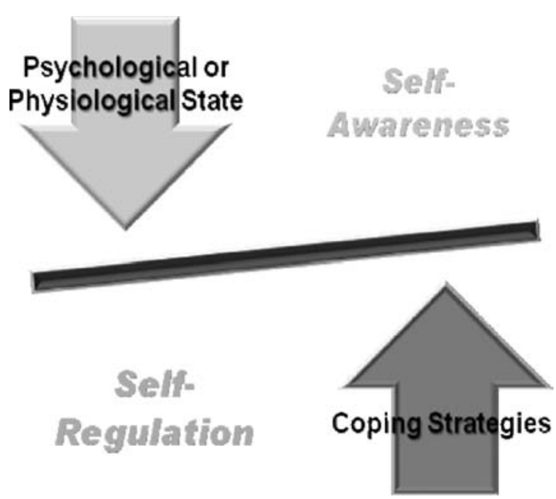

Figure 0.1 The interplay between coping strategies and one's psychophysiological state.

Figure 0.2 Interchange between client, therapist, and BFB.

Schwartz and Andrasik have discussed in various forums the importance and relevance of a patient-education model, which implies that the patient's learning must be the active ingredient of a BFB/NFB intervention en route to generating the required psychophysiological changes. However, it must be noted that, although the client is the key ingredient, the interchange between the therapist, client, and BFB/NFB intervention is critical. As mentioned above, individuals and the contexts in which they operate are all unique; thus, the practitioner must adapt and adjust the intervention to the needs of the client. Therefore, practitioners must combine their theoretical understanding with a sense of creative ingenuity in order to tailor psychophysiological interventions specifically for each client with the aim of producing an optimal performance. This must occur seamlessly and interactively as shown in Figure 0.2.

When designing BFB/NFB interventions, the importance of the context and environment cannot be understated (i.e. client issues/needs are context specific). For example, a practitioner can utilize heart rate variability (HRV) BFB with a senior collegiate golfer who is having trouble with his putting game due to a lack of attentional focus. The golfer is known to have a short attention span, and is known to be impatient. How would a practitioner develop a HRV-BFB protocol specifically for this case? Would this protocol be different from the one that would be designed for his teammate who is a freshman struggling with his chip shot and ability to putt due to high levels of anxiety? Both golfers struggle with putting on the green, but maintain different challenges for different reasons. Therefore, the BFB application and protocols would systematically vary for each performer. While maintaining the general principles of BFB and NFB interventions, the specifics of these applications in track and field, dance, target shooting, soccer, golf, music, and gymnastics vary tremendously depending on the task, the condition, and the client. As a result, the major contribution of this book is to provide students and practitioners a variety of cases to study, and provide the framework of each protocol of the application described in the case to incorporate in his or her practice.

The contributing authors are practitioners in the field of psychophysiology who maintain strong research backgrounds, and who understand the importance of applying sound theoretical frameworks to the applications of their cases. It should be noted that locating authors in the field with such qualifications was a challenging task for us. This is a testament to the fact that few individuals possess the necessary qualities and skills to provide sound and effective BFB/NFB interventions. This book is one of the first steps in addressing the need for building interest among students in the field of BFB and NFB, and allowing practitioners and researchers to learn from the novel techniques utilized in each case.

Intended Audiences and Use

The primary audience of interest is practitioners in the field of psychophysiology who work with both clinical and non-clinical populations. Practitioners with backgrounds in sport psychology, kinesiology, exercise psychology and physiology, sport medicine, and clinical and counseling psychologist would all have interest in the series of case studies. Secondary audiences would include scholars, academicians, and researchers who conduct evaluations in the field. They will find this book useful in understanding the link between theory and practice. In addition, professors in the fields mentioned above can utilize this book in graduate classes and seminars to better train students in a variety of techniques and protocols used with BFB and NFB.

The primary use of this book is for practitioner audiences to learn from the experiences of others in the field of applied psychophysiology. In addition, the book can be used as a mechanism to build interest in students as they learn from a variety of well-established practitioners in the field. For example, professors can utilize this text in applied sport psychology, exercise psychology and physiology, and sport medicine courses. Psychology students on post-doctoral internships and involved in rotations utilizing BFB and NFB will also find the protocols and techniques presented in this text useful and applicable.

Case Presentation

We have included two major Forwards in this book. The first Forward was written by Don Moss and "Sue" Vietta Wilson. They detail the current and past trends related to BFB and performance. The second Forward was written by Siegfried Othmer. Siegfried details the relevant trends and applications of NFB and optimal performance. The two major Forwards are then followed by various cases dealing with peripheral BFB: electromyography, electrodermal activity, temperature, cardiovascular and respiratory BFB (i.e., HRV), and EEG BFB (i.e., NFB). Some of these cases have utilized peripheral BFB in conjunction with the NFB. The authors are Sue Wilson, Lindsay Shaw, Olga Bazanova, Elena Sapina, Ronald Rosenthal, Boris Blumenstein, Iris Orbach, Richard Harvey, Erik Peper, Roland Carlstedt, Tom Kennedy, Diane Roberts Stoler, Jane Arave, and Alex Edmonds. The case presentations are followed up by three relevant chapters. Chris Janelle and Derek Mann discuss various types of equipment and physiological indices related to practice. Tony Hughes and Fred Shaffer discuss BCIA certification and ethics in practice. And Erik Peper and Richard Harvey present a chapter on future directions. Each case is written following a specific format to enhance the understanding of the specific applications. The following headings are suggested when detailing personal cases for publication or presentations:

- *Background information of client* – This section presents the client's background and includes information such as performance level and gender. Information pertaining to the type of event or task the client is involved in, which also includes a detailed description of the task. A history of specific problems relating to the task and details regarding successes, challenges, and failures is presented.
- *Description of the presenting problem (issue)* – This section details the particular issue the client feels he or she is trying to overcome. This includes descriptions of emotions, thoughts, physical descriptors, and how these relate to the barriers to success.
- *Assessment and diagnosis* – This section discusses the practitioner's perspective of the underlying issue, and describes how this conclusion was reached based on the information provided above.
  - Psychophysiological and/or introspective evaluation
- *Intervention* – This section includes a detailed description of the application in a stepwise approach of the technique, and psychophysiological tools used to address the client's issue. The specifics discussed are as follows:
  - Setting of application
  - Equipment used (and software)
  - Protocol (indicate if it's a custom or standardized protocol or a combination)
  - Number of meetings
- *Results* and *discussion of findings* – This section details findings from a physiological standpoint (changes in physiology from start to finish) in addition to the introspective and subjective accounts of the client. Also, it summarizes and provides an overview of the case. This is paired with actual performance-related data.
  - Tables and figures (graphs, pictures)
  - Barriers to success
  - Recommendations for future applications
  - Recommended readings not found in references

About the Editors and Contributing Authors

Editors

W. Alex Edmonds, PhD, BCB
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W. Alex Edmonds is currently a program professor in the Applied Research Center at Nova Southeastern University in North Miami Beach, Florida. He graduated from Florida State University and received his doctoral degree in Educational Psychology with a minor in Statistics and Measurement. Over the years Alex has applied his knowledge of research design, measurement, and assessment in both field and laboratory examinations. He has published extensively in a variety of areas such as psychophysiology and educational psychology. His primary interest revolves around applying unique methodological and statistical techniques as a means to exploring the relationship between emotions and performance in a variety of domains. Alex also has over ten years of experience in conducting research and applying biofeedback in the field. While in graduate school, he conducted his fieldwork with the track and field team at Florida State and started using biofeedback for research and practice during this time. He has utilized biofeedback extensively with various types of athletes for performance enhancement, as well as stress-regulation techniques for individuals with type-2 diabetes and pain management for patients suffering from chronic pain. Alex is certified through the Biofeedback Certification International Alliance in general biofeedback.

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Gershon Tenenbaum, Benjamin S. Bloom Professor of Educational Psychology, a graduate of Tel-Aviv University and the University of Chicago is a Professor of Sport and Exercise Psychology at the Florida State University. He is a former director of the Ribstein Center for Research and Sport Medicine at the Wingate Institute in Israel, and coordinator of the Graduate Program in sport psychology at the University of Southern Queensland in Australia. From 1997 to 2001 he was the President of the International Society of Sport Psychology, and from 1996 to 2008 the Editor of the *International Journal of Sport and Exercise Psychology*. Gershon Tenenbaum has a long history of published research in the fields of sport psychology, psychometrics, motor

movement, and psychophysiology. He is the lead editor of the *Handbook of Sport Psychology* (3rd edition), and the *Handbook of Measurement in Sport and Exercise Psychology*, and has co-edited relevant texts such as *Brain and Body in Sport and Exercise: Biofeedback Applications in Performance Enhancement*. Gershon received several distinguished awards for his academic and scientific achievements, and is a member and fellow of several scientific and professional forums and societies.

Contributors

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Jane Arave is currently in private practice in Columbia, South Carolina. She is a Licensed Professional Counselor and has been doing biofeedback and neurofeedback for the past nine years. Jane graduated from the University of South Carolina with a degree in Experimental Psychology. She received her Master's Degree in Counseling from Columbia International University. She continues to do psychotherapeutic counseling along with neurofeedback and biofeedback. She became interested in working with athletes in 2006 and has enjoyed many successes with athletes from different sports. Jane is BCIA certified in both biofeedback and neurofeedback.

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Olga M. Bazanova currently is senior researcher for the Institute for Molecular Biology and Biophysics of the Siberian branch of the Russian Academy of Medical Sciences in Novosibirsk, Russia. She graduated from Novosibirsk State University and received her doctoral degree in Physiology with a minor in Adrenal Steroids Endocrinology and Vessel Reactivity. She received her Doctor of Science degree in Psychophysiology. She conducted her EEG work with the musicians at Novosibirsk and Magnitogorsk State Musical academies and started using biofeedback for research and practice during her time in psychophysiology teaching in these academies. She has utilized biofeedback extensively with various specialties of musicians for performance enhancement, as well as stress-regulation techniques for individuals with ADHD and pain management for patients suffering from chronic pain. Dr Bazanova is certified through the Biofeedback Certification Institute of Russia in general biofeedback and is currently doing research and practice with biofeedback applications.

Boris Blumenstein, PhD
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Boris Blumenstein is the Director of the Department of Behavioral Sciences at the Ribstein Center for Sport Medicine Sciences and Research, Wingate Institute, Netanya, Israel. He received his PhD in Sport Psychology in 1980 from the All Union Institute for Research in Sport, Department of Sport Psychology, Moscow,

Russia (former USSR). His extensive experience in sport psychology spans some 30 years, culminating in applied work at the elite level. He has been a sport psychology consultant for the Soviet national and Olympic teams and since 1990 to the Israeli national and Olympic teams (including delegations to Atlanta, 1996; Sydney, 2000; Athens, 2004, and Beijing, 2008). He is author and coauthor of over 90 refereed journal articles and book chapters, mainly in area of sport and exercise psychology, and senior editor of the book *Brain and Body in Sport and Exercise: Biofeedback Applications in Performance Enhancement* (John Wiley & Sons, Ltd, 2002) and *Psychology of Sport Training* (Meyer & Meyer Sport, 2007). He has also given more than 80 scientific presentations at international and national conferences and workshops. His current research interests include mental skills training for performance, stress-performance relationship, effectiveness of different mental interventions, and athletic competitions readiness. In addition, he is the past President of the Israeli Society for Sport Psychology.

Roland A. Carlstedt, PhD, ABSP, BCB
American Board of Sport Psychology
Roland A. Carlstedt is a licensed clinical psychologist and board-certified in sport psychology and in biofeedback. He is the chairman and head mentor of the American Board of Sport Psychology. He is also the holder of an applied psychologist's license. Roland earned his PhD in psychology with honors from Saybrook Graduate School (with emphases in health and sport psychology and psychophysiology) in San Francisco, under Dr Auke Tellegen of the University of Minnesota. Roland has completed postdoctoral continuing education in psychiatric neuroscience through Harvard Medical School, and received training in the joint Massachusetts General Hospital–Massachusetts Institute of Technology–Harvard Medical School Athinoula A. Martinos Center for Biomedical Imaging Visiting Fellowship in Functional Magnetic Resonance Imaging (fMRI) and NIH-sponsored Multi-Modal Brain Imaging program. He is a member of the Massachusetts General Hospital Psychiatry Academy, a research fellow in applied neuroscience with the Brain Resource Company and the clinical and research director of Integrative Psychological Services of New York City. He also serves on the Advisory Board of BioCom Technologies. Dr Carlstedt, is a former professional tennis player and was a full-time consultant and coach on the professional tennis tours for over 15 years. Roland continues to works with numerous elite athletes, teams and sport federations internationally and directs the American Board of Sport Psychology's annual summer Fellowship and Training programs in New York City.

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Richard Harvey, PhD is a board member (and past-president) of the Biofeedback Society of California, the San Francisco Psychological Association, and chairperson of the American Public Health Association, Alternative and Complementary Health Practices Special Interest Group, promoting biofeedback techniques in the public

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Tony Hughes has been a practitioner and instructor of integrative mind body therapy for over 30 years. He is nationally recognized as an exceptional teacher and one of the most experienced professional trainers in the field of applied psychophysiology and biofeedback. Licensed as a Marriage-Family Therapist and Board Certified in Biofeedback, his seminars are geared to preparing professional clinicians to use biofeedback, Autogenic Training and other techniques of autonomic self-regulation for the treatment of stress-related and pain disorders. Since 1978, he has been consultant to a number of hospitals and clinics helping to establish programs in pain management and wellness. Dr Hughes teaches biofeedback and neurofeedback certification courses for the Stens Cooperation and practices privately in Berkeley, CA.

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Christopher Janelle is Associate Professor and Director of the Performance Psychology Laboratory in the Department of Applied Physiology and Kinesiology at the University of Florida. His research interests focus on the interaction of emotion, attention, and movement as related to human performance and health issues. He has published over 60 scientific papers in refereed journals and seven book chapters, and he has presented his research worldwide. He also authored the *Handbook of Sport Psychology* and is on the editorial boards of five journals, including the *Journal of Sport and Exercise Psychology* and the *International Review of Sport and Exercise Psychology*. Dr Janelle received the Dorothy Harris Memorial award for early career excellence by the Association for Applied Sport Psychology. He was recently named a University of Florida Research Foundation Professor. In addition to his scholarly work, Dr Janelle serves as a sport psychology consultant to collegiate, Olympic, professional, and youth sport athletes.

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Derek Mann received his PhD in Sport Sciences from the College of Health and Human Performance the University of Florida. Derek is currently a performance enhancement consultant and co-founder of the Performance Psychology Group, LLC (PPG), an organization responsible for providing coaching services to athletes and corporate executives. He has spent several years investigating the impact of emotion on human performance with elite populations, which has been published in several leading professional and academic publications where he has also serves as a contributing editor. Dr Mann has also served as Manager of Research and Development at Multi-Health Systems, where he has contributed to the growth and accessibility of emotional information through assessment, training and development, and professional presentations throughout North America and Europe.

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Donald Moss is Chair of the College of Mind-Body Medicine, at the Saybrook University in San Francisco. He is chief editor of the *Handbook of Mind-Body Medicine for Primary Care* (Sage Publications, 2003) and *Humanistic and Transpersonal Psychology: A Historical and Biographical Sourcebook* (Greenwood Press, 1998), and chief editor of *Biofeedback* magazine, and consulting editor for *Journal of Neurotherapy, Psychophysiology Today,* and *Journal of Phenomenological Psychology.* He has published over 50 articles and chapters on consciousness, psychophysiology, spirituality in health, and integrative medicine. His publications on mind-body medicine have been translated into Chinese, German, Polish, Hebrew, and Spanish, and he regularly presents workshops in countries from Australia to China to Mexico and Germany. He is currently preparing a new book on mind-body assessment and treatment, *Pathways to Illness, Pathways to Health* (Springer). He operates two clinics in Michigan, providing mind-body services for anxiety, PTSD, functional medical problems, and chronic pain. Dr Moss is the president of Division 30 (hypnosis) of the American Psychological Association, an Executive Council member and Fellow of the Society for Clinical and Experimental Hypnosis, Chair of Certification for the Society for Clinical and Experimental Hypnosis, and a Board member of the Biofeedback Certification International Alliance and the Biofeedback

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Iris Orbach is a researcher and a sport psychology consultant in the Department of Behavioral Sciences at the Ribstein Center for Sport Medicine Sciences and Research, Wingate Institute, Netanya, Israel. She received her PhD in Sport Psychology in 1999 from the University of Florida, Department of Sport and Exercise Sciences, Gainesville, Florida, USA. She worked as an assistant professor in the Department of Sport, Fitness and Leisure Studies in Salem State College for eight years. In addition to teaching, Orbach has published numerous articles and book chapters and presented in national and international conferences on topics related to sport psychology. Her current research interests include stress-performance relationship, children and motivation in sport, and the effectiveness of different mental training. Dr Orbach also uses her psychology skills as a consultant for athletes at all skill levels. In her free time, Dr Orbach enjoys running, bicycles, swimming, weight lifting, and all kind of fitness activities.

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The Brian Othmer Foundation

Siegfried and Susan Othmer have been engaged in the professional development of neurofeedback in various aspects since 1985, in consequence of their son having been helped for his seizure disorder. They have been involved in instrumentation development (NeuroCybernetics and Cygnet); clinical service delivery (The EEG Institute); professional training (EEG Info); and clinical research (The Brian Othmer Foundation). Dr Othmer is currently Chief Scientist of the EEG Institute and President of the Brian Othmer Foundation. Susan Othmer is Clinical Director at the EEG Institute, which is located in Woodland Hills (Los Angeles). The Othmers have pioneered a number of novel applications of neurofeedback over the years. The Othmers provide professional training in EEG biofeedback and sponsor a professional network of neurofeedback therapists, the EEG Associates. The Othmers have been developing premier instrumentation for neurofeedback continuously over the last 22 years, and this development is ongoing.

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Erik Peper is an international authority on biofeedback and self-regulation and since 1971 he has been researching factors that promote healing. He is Professor of Holistic Health Studies in the Department of Health Education at San Francisco State University. He is President of the Biofeedback Foundation of Europe and past President of the Association for Applied Psychophysiology and Biofeedback. He holds Senior Fellow (Biofeedback) certification from the Biofeedback Certification Institute of America and has a biofeedback practice at Biofeedback Health. He received the 2004 California Governor's Safety Award for his work on Healthy Computing. He is an author of numerous scientific articles and books such as *Muscle Biofeedback at the Computer, Make Health Happen* and *De Computermens*. His most recent published book by AAPB is *Biofeedback Mastery*. He is co-author of the upcoming book, *Fighting Cancer,* which will be published in 2011 by North Atlantic/Random House. He is a recognized expert on stress management and workplace health who has been featured on ABCNews.com and in *GQ*, *Glamour, Men's Health, Reader's Digest,* the *San Francisco Chronicle, Shape,* and *Women's Health*. Dr Peper, who lectures and teaches frequently all over the world, has been the editor of *Psychophysiology Today* since 2004. His research interests focus on psychophysiology of healing, illness prevention, voluntary self-regulation, holistic health, healthy computing, respiratory psychophysiology and optimizing health with biofeedback.

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Ronald Rosenthal is a licensed psychologist in Miami, Florida. He is a member of the psychology department at Baptist Hospital. Dr Rosenthal's training was initially in experimental psychology and he was a post-doctoral research associate with Professor Neal Miller of Rockefeller University in New York City. He completed a retraining program in clinical psychology at the University of Miami and studied clinical biofeedback with Dr Bernard Brucker at the school of medicine. Dr Rosenthal's special interest is in the treatment of motor dysfunction with multiple-channel surface EMG training. He has been involved in biofeedback professional organizations on both the state and national level and has served as president of the Biofeedback Society of Florida and on the board of directors of AAPB.

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Fred Shaffer is a biological psychologist and professor of Psychology and former Department Chair at Truman State University, where he has taught since 1975 and has served as Director of Truman's Applied Psychophysiology Research Lab since 1977. In 2008, he received the Doris and Walker Allen Fellowship for Academic Excellence. He also serves on the Saybrook Graduate School faculty in their Mind-Body Medicine and PsyD programs. Dr Shaffer is the author of *Biofeedback Tutor* (2011), a multimedia tutorial in biofeedback. He co-authored with Donald Moss, PhD, *A Biofeedback Primer*, to be published in Lublin, Poland, and a chapter on biofeedback in the *Textbook of Complementary and Alternative Medicine* (2nd edn). He co-authored with Mark S. Schwartz, PhD, BCB, a chapter on entering the field and assuring competence in *Biofeedback: A Practitioner's Guide* (4th edn). He is a consulting editor for *Biofeedback: Clinical Journal* and contributing editor for *Applied Psychophysiology and Biofeedback*. Dr Shaffer is a Senior Fellow in

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Lindsay Shaw, EdD
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Lindsay Shaw did her undergraduate work at the University of Pennsylvania and her graduate work at Boston University under Dr Len Zaichkowsky. She was trained in biofeedback and neurofeedback by Dr Sue Wilson and Drs Michael and Lynda Thompson, and did her dissertation research testing the efficacy of biofeedback and neurofeedback training on competitive athletic performance. She has a private practice in Boston, MA and continues to conduct research on the influence of psychophysiological activity and training on performance outcomes.

Diane Roberts Stoler, EdD
Catalyst for Change®
Diane Roberts Stoler received her EdD from Boston University in education. She conducted her postdoctoral work at Harvard University where she studied in the Department of Psychology and Social Relations. Dr Stoler, Board Certified Health Psychologist and Board Certified Sports Psychologist has worked with amateur, professional and Olympic athletes to help them achieve Peak Performance and be in "The Zone." Prior to her work as a psychologist, she worked in two diverse fields: Special Education and Business. As an educator of special needs, she was an instructor at Tufts University and worked as a Special Needs Auditor for the Commonwealth of Massachusetts. In the field of business, she was trained as a cost accountant and taught cost accounting at Stonehill College, Fisher College and Chamberlain College. Through her experience as a cost accountant and business woman, she has worked with CEOs, CFOs and many others to help them develop the Resilient Mind needed to achieve excellence in their careers. She is the author of two leading books in the field, *Coping with Mild Traumatic Brain Injury* and *Seven Hypnosis Scripts in Handbook of Hypnotic Suggestions and Metaphors*. Dr Stoler is a survivor of a stroke and four traumatic brain injuries, including brain surgery. She was told by all her doctors in 1994, including some of the top neurologists in Boston, that she was permanently brain damaged and would never get better. She is eternally grateful for the field of neurofeedback and her clinical work with Paul Swingle, PhD.

"Sue" Vietta Wilson, PhD
York University
"Sue" Vietta Wilson a Senior Scholar at York University, graduated from University of Utah, University of Arizona and University of Oregon specializing in sport and applied psychology. Her first Bf/Nf clinical experiences were in the 1970s with research following in the 1980s. She has taught and developed Bf/Nf software for optimizing performance that is used throughout the world. She believes that clinicians can facilitate performance assessment, training and problem solving through the use of psychophysiological measures.

Part I

General Biofeedback and Neurofeedback Forwards

1

The Use of General Biofeedback in the Pursuit of Optimal Performance

Donald Moss and "Sue" Vietta Wilson

Introduction

Since the opening days of the biofeedback movement in the late 1960s and early 1970s, the biofeedback paradigm has excited visions of expanding human potential (Moss, 1999). Early biofeedback research showed human beings gaining enhanced awareness and control over visceral physiology (Miller, 1969), musculature (Basmajian, 1967), and states of consciousness (Kamiya, 1969). Barbara Brown, a founder and the first president of the Biofeedback Research Society, proclaimed that biofeedback could give to the human being a *new mind* and a *new body* (Brown, 1974). Later, she imaged this new mind as a *supermind* with expanded consciousness and unlimited potential (Brown, 1980).

Much of Barbara Brown's work, and much of the early speculation rested on the hope that EEG biofeedback would awaken human creativity and enable human beings to reach higher states of consciousness. Using EEG biofeedback to optimize performance is discussed in later chapters. Nevertheless, general biofeedback and EEG biofeedback have been used in tandem, as complementary tools to provide human beings with enhanced awareness of their mind-body lineage, increased control over their physiology, and increased access to self-regulation strategies.

Part I of this book provides examples highlighting the use of General Biofeedback in optimal performance work, including work to enhance the performance of athletes in sport, improve the learning of students in the classroom, and intensify the creativity and performance of artists in music, the graphic arts, and other artistic arenas. Clinical application and research investigations with biofeedback have steadily grown since the 1970s. Readers seeking additional general information are

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referred to the following sources: Blumenstein, Bar-Eli, and Tenenbaum (2002); Collins and McPherson (2006); Hatfield and Landers (1983); Leonards (2003a,b); Petruzzello, Landers and Salazar (1991); Sime (1985); Strack and Sime (2011); Tenenbaum, Corbett, and Kitsantas (2002); and Zaichkowsky and Fuchs (1988). Readers interested in learning more about applications of EEG and neurofeedback to sports are referred to Thompson *et al.* (2008); Hatfield, Haufler, and Spalding (2006); Hatfield and Hillman (2001); Lawton *et al.* (1998); Vernon (2005); and Wilson, Sime, and Harkness (in press for 2011).

Paradigms in Biofeedback Assisted Optimal Performance Work

Several conceptual paradigms have been utilized by biofeedback professionals in optimal performance work. Although they overlap, each highlights a dimension or direction for applying biofeedback to remove impediments to performance and elicit maximal physiological responsiveness.

The relaxation paradigm

In clinical biofeedback, cultivation of the "relaxation response" is a central model driving the majority of biofeedback applications (Benson, 1975). In general, autonomic nervous system vigilance and tense and braced musculature are not conducive to optimal functioning in sports (see Zaichkowsky and Fuchs, 1988, for a review), music, and stage performance. Biofeedback assisted relaxation therapy can counteract many of the negative effects of stress in performance. In addition, biofeedback-assisted relaxation can affect functional measures reflective of athletic performance. Caird, McKenzie, and Sleivert (1999), for example, utilized multi-modal biofeedback (heart rate and respiratory measures) to augment relaxation training in long-distance runners, and showed improvements in running economy, peak oxygen consumption, and peak running velocity. Similarly Wilson and Bird (1981) compared relaxation and muscle biofeedback for flexibility to a control condition, and showed that both relaxation and biofeedback produced improved hip flexion in gymnasts.

Alleviating dysponesis

Many performing artists and athletes develop neuromuscular pain problems, some of them recurrent and eventually chronic, due to kinesiologically inefficient postures and tension patterns during performance. The Whatmore and Kohli (1968, 1974) concept of *dysponesis* (misplaced effort or maladaptive tensing of the musculature) highlights the essence of this problem: Organisms suffer from misdirected effort. The nineteenth century Shakespearean actor F.M. Alexander studied his chronic vocal problems, and identified destructive postural patterns constricting the vocal chords. His self-care evolved into the Alexander Technique, in which therapists study postural misalignment as the source of a variety of symptoms (Moss and Shane, 1999). A current example of alleviating dysponesis with biofeedback is seen in Riley (2011), who identified maladaptive postures and alignment in pianists, measurable with surface electromyography (SEMG); these patterns produce high levels of muscle tension, fatigue, discomfort, and pain. There is a musical performance deficit as well, when muscles suffer repetitive strain. Riley uses SEMG biofeedback and video feedback to retrain posture at the keyboard.

Moderating anxious cognitive processes

Ruminative and anxious thinking frequently hinders optimal responsiveness on the athletic field. Vietta Wilson has utilized EEG training to combat “busy brain,” training athletes to respond instinctively and without nonproductive thought processes (Wilson, Peper, and Moss, 2006; Wilson, Sime, and Harkness, in press). Also, Lagos *et al.* (2008) have utilized heart rate variability biofeedback to reduce anxious thoughts as a means to improve golf performance in a single case.

Resolving psychological distress that undermines optimal performance

Physiological tension is often an accompaniment of lingering psychological conflicts, traumatic experiences, and conflicts. Biofeedback can be paired with psychologically oriented therapies to more effectively resolve the psychological problems. Leddick (2011) reported on an integrative approach combining neurofeedback with psychoanalytic psychotherapy in the treatment of an under-achieving musician. Wilson and Peper (2011) combine a number of biofeedback and neurofeedback modalities with a cognitive approach to resolving serious anger episodes in a teen tennis player. The biofeedback training seems to facilitate the psychological resolution and vice versa.

Enhancing optimal physiological responsiveness

Relaxation is not the answer to every competitive problem. Rather, the capacity to relax away maladaptive tensions, while exerting with an optimal level of intensity in critical moments, provides a more comprehensive approach (Taylor, 1996). Skill training is critical in sports and performing arts, and the performer needs to develop an instinctive recruitment of skills in response to ever-changing demands in the moment. Prior to successful performance there is a deceleration in heart rate (HRD) and this corresponds to faster reaction and accompanies a process of orientation and readiness. Researchers such as Hatfield, Landers, and Ray (1984); Landers *et al.* (1980); and Wang (1987); and Landers, Boutcher, and Wang (1986) confirmed this was the case in sport performance, mainly with shooters. Carlstedt (2001) utilized ambulatory monitoring, and showed that HRD was evident prior to action phases in tennis. In his sample, the competitors with greater HRD won the matches.

Reducing reaction time

The outcomes of many track and field events are determined by how quickly the participant can get off the blocks. Reaction time training involves focusing interventions on reducing that initial reaction time. Vietta Wilson (2001) used reaction time training from the blocks for sprinters prior to the 1988 Olympics. Pierre Beauchamp and colleagues applied reaction time biofeedback to training Canadian speed skaters in preparations for the Vancouver 2010 Winter Olympics (Harvey *et al.*, 2011). The authors emphasized reaction time as one factor, in conjunction with pre-start routine, start technique, start power and acceleration, and start confidence, in preparing the skaters for Olympic gold.

The Field of Optimal Performance Psychophysiology

Optimal performance psychophysiology: Defined

The related fields of optimal performance psychophysiology, sports psychophysiology, and performing arts psychophysiology all seek to apply the tools of stress management, muscle kinesiology, biofeedback, and neurofeedback, to remediate performance related disorders and to optimize performance. The approach of psychophysiology emphasizes the indivisibility of mind and body, and the value of integrating behavioral, mental, and physiological tools for performance focused interventions. The ultimate question framing this field is: How can we utilize psychophysiological tools and approaches to enable human beings to reach their highest level of performance and functioning.

Applications of optimal performance psychophysiology

Optimal Performance Psychophysiology has obvious value for elite performers on the stage and the athletic field, as well as for the teen athlete, the athlete in training, and musicians and stage performers at all levels of expertise. Further, there is also value in transferring the optimal performance paradigm to clinical treatment and other sectors of life. There are instances in clinical treatment where an over-focus on alleviating pathology or problems produces a diminished concept of the human being, and self-limits the possible results. Although this will not be the emphasis of this section of the book, it is useful to pose to clinical patients or business executives the optimal performance question: How can we organize your energy and our interventions to help you become everything that you are capable of becoming?

A Brief History

The history of psychophysiological approaches to sports performance pre-dates the era of modern biofeedback. Coleman Roberts Griffith, who is regarded as the "father of sports psychology," began scientific study of the effects of psychological factors on athletics in 1918, and highlighted the place of psychomotor skills, and the measurement of reaction time (Kroll and Lewis, 2007). He demonstrated the importance of utilizing a laboratory for research in athletics (Griffith, 1930). Many of the basic scientific principles now utilized in sport psychophysiology also predate the biofeedback movement. The neurophysiology of the musculature was outlined first by Edmund Jacobson (1938) and later by John Basmajian (1967). The relationship between heart rate deceleration and performance was outlined by Lacey and Lacey (1974) and Porges (1972). Although research was being completed in biofeedback and sport since the early 1970s, the birth of sport psychophysiology as a self-conscious movement, goes back only three decades, to a breakthrough paper by Zaichowsky and Sime (1982), which advocated the application of stress management concepts in the newly defined field of sport psychophysiology.

Since 1982, several individuals have actively strived to move the field of optimal performance psychophysiology forward: Wesley Sime (2003), Vietta Wilson and Erik Peper (Wilson and Peper, 2011), Marcie Zinn (Zinn and Zinn, 2003), Len Zaichowsky (Zaichkowsky and Fuchs, 1988), Gershon Tenenbaum (Tenenbaum, Corbett, and Kitsantas, 2002), and Rae Tattenbaum (Tattenbaum and Moss, 2011).

Biofeedback Tools for Optimal Performance: Modalities

Biofeedback applications to optimal performance have utilized surface electromyography (SEMG), and electroencephalography (EEG) extensively, and temperature, heart rate, heart rate variability, electrodermal measures, and respiration to a lesser extent. We turn now to a discussion of these modalities, with the exception of EEG, which is discussed elsewhere in this book.

Surface electromyography

Early work in the use of general biofeedback for optimal performance relied heavily on the surface electromyograph (SEMG), and this measure of muscle tension patterns has continued to be useful, especially in overcoming maladaptive muscle habits that inhibit more effective performance, and which lead to the many pain syndromes plaguing athletes and performance artists. George Whatmore and Daniel Kohli (1974), mentioned earlier for advancing the concept of dysponesis, used eight channels of SEMG monitoring to identify specific destructive muscle habits. Later this concept of muscular dysponesis was applied by a variety of individuals within the biofeedback movement, to identify self-defeating muscle habits affecting both athletes and performing artists. Early leaders in this direction were Wilson and Bird (1981) and Cummings, Wilson and Bird (1984), who used the SEMG to reduce muscle tension in the hamstring of gymnasts and increase their flexibility, and to improve flexibility in sprinters.

Electrodermal activity

The electrodermograph (EDR) imposes an imperceptible current across the skin and measures how easily it travels through the skin. When anxiety raises the level of sweat in a sweat duct, conductance increases (Shaffer and Moss, 2006). The EDR is a useful biofeedback tool for cognitive quieting and emotional regulation. Ideally, athletes will shift spontaneously and flexibly between cognitively quiet states and maximal arousal and attunement. EDR is useful in training the self-quieting. Wilson, Sime, and Harkness (in press) show that EDR is useful in desensitizing the disruptive emotions reactive to past failures, falls, injury, and the like, allowing the athlete to enter practice and competition with a calmer more optimal emotional state.

Temperature

Peripheral skin temperature is a useful tool in psychophysiological assessment and in relaxation training. Skin temperature mainly reflects arteriole diameter. Hand-warming and hand-cooling are produced by separate mechanisms and their regulation involves different skills. Increased sympathetic activation associated with anxiety and hypervigilance can produce vasoconstriction and hand-cooling. In athletics, the psychophysiologist must become familiar with what is optimal and normal for various sport events and in each stage in a competition (Wilson, Sime, and Harkness, in press). Wilson reports that elite endurance athletes such as skaters and marathon runners show cooler peripheral temperatures in nonstressful times, which is probably an adaptive response to the demands of the event.

More frequently in biofeedback practice, even with athletes, cool hands are interpreted as a sign of a stress response, and hand-warming is used as a tool to facilitate relaxation. Thermal biofeedback has been shown in one study to be effective in facilitating improved performance in cold weather sports, such as hockey and curling (Kappes and Chapman, 1984). This may be important to the athlete's dexterity in manipulating equipment in outdoor sports. Harkness (2009) reported using hand-warming training with an Olympic shooting gold medalist, but with mixed results. One positive advantage of thermal training is that athletes and stage performers can learn to self-monitor skin temperature as one index for performance related stress, and can also utilize hand-warming and imagery for effective self-relaxation.

Respiratory biofeedback

Breath control is critical in athletics for optimal performance and for its autonomic regulatory effects. Anxiety and stress-oriented thinking disrupts the breath pattern, and undermines the chemistry surrounding the respiratory cycle, including carbon dioxide levels and the body's acid base balance. One study used breath training without biofeedback, and showed that paced slowed breathing dramatically reduced arterial hypertension during heavy, dynamic weightlifting, thereby reducing health risk to the athletes (Narloch and Brandstater, 1995). Respiratory biofeedback is a useful assessment tool, and a useful tool for retraining effortless, relaxed diaphragmatic breathing and autonomic regulation. Respiration is also a component within heart rate variability training, which will be discussed below.

Emerging trends: Cardiovascular measures

At present, heart rate (HR) and heart rate variability (HRV) are gaining ground both as indices of autonomic dysregulation, and as tools for relaxation and autonomic regulation. Lopes and White (2006) reviewed the significance of heart rate and heart rate variability (HRV) for athletics. Aerobically fit young athletes tend to exhibit lower resting heart rates, and greater heart rate variability (more prominent respiratory sinus arrhythmia, or heart rate oscillations in phase with the breath cycle) than non-athletes. Research studies (Porges, 2007; Thayer and Lane, 2009) also show that heart rate variability is associated with improved physiological, emotional and cognitive performance, which is believed to be due to the increased communication between the heart and brain. Athletes have been shown to have higher levels of HRV when compared to non-athletes, which is attributed to increased parasympathetic activity (Puig *et al.*, 1993).

Heart rate variability biofeedback training increases variability further with a variety of effects reported. Heart rate variability biofeedback has been reported to improve reaction time and relaxation in wrestlers (Vaschillo, Visochin, and Rishe, 1999) and batting performance in baseball by 60% (Strack, 2003). Heart rate variability was also found to be a viable and convenient measure of arousal in pre-competitive situations for golfers (Murray and Raedeke, 2008). Bruno de Michelis, the trainer for the AC Milan soccer group, utilizes a specific respiration training pattern along with HRV training, to create maximal heart rate oscillations, with enhanced athletic resilience (Wilson, Peper, and Moss, 2006). One study (Tanis, 2008), however, found no improvements in performance for female volleyball players who trained with heart rate variability biofeedback.

Heart rate variability has also been utilized for calming and optimal autonomic balance. In 2008, Lagos *et al.* (2008) published a case study describing the use of heart rate variability biofeedback with a teen golfer, alleviating his performance anxiety and improving his competitive play. Later Lagos *et al.* (2011) provided a follow-up study, integrating heart rate variability biofeedback with virtual reality training to enhance golf performance.

Standards for Application

The field of sport psychophysiology and performance psychophysiology is not yet standardized, and few guidelines exist for consistency in intervention protocols or for research. The field is still at a stage where much of the useful work is reported in case studies, in part because the sport psychophysiologist is almost always responsible to the athletic coach or trainer, and the competitive performance priorities win out over research.

Professional Resources

Organizations

The field of general biofeedback is represented by a professional society in North America, the Association for Applied Psychophysiology and Biofeedback (AAPB), which supports three professional publications, holds an annual meeting, and supports webinars and other workshops. The European equivalent for AAPB is the Biofeedback Foundation of Europe. In addition, there is a certification organization, the Biofeedback Certification International Alliance, which establishes a standard for knowledge and skills for the field, and provides certification programs in general biofeedback, neurofeedback, and pelvic floor biofeedback. A third organization, the International Society for Neurofeedback and Research, focuses on neurofeedback (EEG biofeedback), but includes some programs in general biofeedback in its conferences.

Division 47 of the American Psychological Association is dedicated to sport, exercise, and performance psychology, with little emphasis on psychophysiology. Nevertheless, for those individuals in the field who are psychologists, Division 47 offers a journal and newsletter, and a link to the organized resources of the America Psychological Association.

Journals

The scholarly journal published by AAPB is called *Applied Psychophysiology and Biofeedback* (formerly *Biofeedback and Self-Regulation*). Over the past 35 volumes, APB has published many articles on optimal performance, such as: (a) the Wilson and Bird (1981) early report on two studies applying biofeedback assisted muscle relaxation training or relaxation alone first to 10 male gymnasts and then to 15 female gymnasts; with evidence in the first study showing relaxation in both groups enhanced hip flexion; (b) the Morasky, Reynolds, and Sowell (1983) study that provided clarinet players with SEMG training, and showed reduction in muscle tension while musical performance measures remained at or above baseline levels, (c) the Bolliet, Collet, and

Dittmar (2005) report on the measurement of six autonomic variables, (d) the Raymond, Sajid, Parkinson, and Gruzelier (2005) study that compared neurofeedback, heart rate variability training, and a control conditions in ballroom and Latin dancers, and found performance benefits for both biofeedback groups, and not in controls, and Vernon's (2005) critical review of the evidence for neurofeedback applications to optimal performance.

AAPB also sponsors a second publication, *Biofeedback*, which has published three special issues on optimal performance, and a number of individual reports on optimal performance work in sports, music, and other performing arts. In 2002, *Biofeedback* published a special issue, entitled "Performing Arts Psychophysiology through the Lifespan." The issue was edited by Donald Moss and Marcie Zinn, and included a broad range of applications of general biofeedback to the performing arts, including an overview of the use of psychophysiological approaches to the performing arts (Zinn and Moss, 2002), an article by John Gruzelier (2002) on his groundbreaking applications of EEG biofeedback to music performance, a case report on applying "constraint induced movement therapy for focal hand dystonia in musicians" (Candia *et al*., 2002), and an annotated bibliography of publications on psychophysiological interventions for the performing arts, by Marcie Zinn (2002).

In 2003, Jeffrey Leonards provided a comprehensive review, in two articles, of the progress in the application of biofeedback with athletes, and highlighted the burgeoning field of sport psychophysiology as an applied science in its own right, with a growing evidence base.

In 2006, the Italian soccer team utilized a panoply of general biofeedback and EEG biofeedback tools on their way to the World Cup. Vietta Wilson, Erik Peper and Donald Moss (2006) then published in *Biofeedback* a broad review of the use of biofeedback and neurofeedback in sports. The article examined those biofeedback techniques known to be used in the so-called "Mind-Room" for the Italian soccer team, and highlighted four components widely used in sports psychophysiology: the training of optimal pre-performance states, the multimodality assessment and training of optimal physiological functioning, the desensitization of anxious or otherwise maladaptive responses, and the inhibition of disruptive inner self-talk and negative self-focus. In 2009, Timothy Harkness also reported on his use of biofeedback to coach India's first gold medalist competitive shooter.

In Spring 2011, *Biofeedback* published an additional special issue, under the leadership of guest editor Rae Tattenbaum, highlighting a broad range of articles documenting the maturing of optimal performance biofeedback and neurofeedback work. A further special issue on optimal performance will appear in Fall 2011, and will feature reports on international applications of the psychophysiological paradigm to optimal performance.

Those interested in the field may also benefit from access to the journals *Sport, Exercise, and Performance Psychology*, *Journal of Sport Psychology*, and *Journal of Clinical Sport Psychology*.

Conclusion

Optimal potential has been a dream and an objective within the biofeedback movement from the beginning. Optimal performance work now guides athletes to more competitive performance, enhances the performance of dancers and musicians, and awakens the creativity and focus of artists alike. Optimal performance work also provides the tools to alleviate the injuries that so often accompany repetitive strain and motion in both the arts and sport. Most of the modalities of general biofeedback have been used to some advantage in optimal performance work: surface electromyography, electrodermal biofeedback, thermal biofeedback, respiratory training, and heart rate and heart rate variability biofeedback. The tools of general biofeedback are used alone, or in conjunction with electroencephalography. The body has a head, and the effects of peripheral and central interventions are complementary and often augment one another. The chapters in this section provide an excellent view of the field as it is evolving today.

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2

Performance Enhancement Applications of Neurofeedback

Siegfried Othmer and Susan F. Othmer

Introduction

Neurofeedback offers a promising complement to peripheral biofeedback in applications to performance enhancement. The present chapter is an overview of the current status of the field, spiced with a mixture of "technology forecasting" to project where these developments may lead. For purposes of this discussion, neurofeedback is understood in its original meaning, namely as a more modern term for EEG biofeedback, the use of biofeedback with the EEG as the working variable.

At this point in our history, neurofeedback is just coming to define its proper role in the field of performance enhancement. The predominant thrust in neurofeedback has been to address a variety of clinical conditions. This was not always so. Ironically, it was EEG biofeedback that provided the first impetus for the formation of a biofeedback organization in the United States in 1969. Joe Kamiya's work with alpha training was the inspiration, and the interest was mainly around the question of EEG correlates of psychological states rather than the remediation of functional pathology. Kamiya himself never worked with clinical populations, and the groups that Kamiya inspired early on were not primarily oriented toward expunging functional deficits either. This included the group around Elmer Green at the Menninger Foundation, the work of Lester Fehmi, and the work of Jim Hardt. The driver was enhancement of human functioning in nonclinical populations (Fehmi and Robbins, 2007; Hardt, 2007).

Ironically, it was also the nonclinical reports that initially made professionals skeptical about alpha training. Researchers were inclined to dismiss claims of spiritual and other transformational experiences. Over the succeeding decades all

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of the early claims have received additional support, and we can now understand how matters went so badly awry early on. The dramatic effects of alpha training were isolated events, not the systematic response to training. They were more likely to occur among those who were naturally drawn to try alpha training, such as the wounded souls finding refuge in drugs at the Haight-Ashbury. They were less likely to occur among the nonclinical populations being drawn from graduate programs for university-based studies of alpha training. So the nonclinical focus of alpha research rendered us blind to the most potent applications of alpha training, namely to the recovery from psychological trauma.

At the Menninger group, biofeedback methods were applied in the same nonclinical frame as were EEG techniques. In fact, both were used seamlessly together, and that may even represent a workable model for nonclinical applications in the future. At the time, however, that model did not propagate. The whole biofeedback field has had to live through the period in which EEG training fell into some disrepute, and where its practitioners were no longer welcome at meetings. Matters were probably well beyond any chance of "self-recovery," i.e. where alpha training could bootstrap its way back into favor. Even when Eugene Peniston first presented his stunning results for PTSD and alcoholism in Vietnam era veterans at the AAPB Meeting in 1990, he was met with a radically rejectionist response from the biofeedback community (Peniston, 1998).

EEG biofeedback reentered the conversation through the work of M. Barry Sterman and Joel Lubar on seizure disorders and ADHD, respectively. Sterman placed into the literature a line of research leading to the establishment of an animal model, and the fortuitous discovery of EEG feedback in the course of that work turned out to have met criteria for a totally controlled, double-blind design. The research gold standard had been met – albeit by accident – right in the very first study (Robbins, 2008).

Sterman's work yielded two principal benefits. On the one hand, it could be seen as providing the most rigorous formal basis for the operant conditioning model of EEG feedback, and yet at the same time it left the biofeedback field essentially undisturbed in the practical realm. Biofeedback therapists simply weren't likely to take up work with seizure disorder. They could readily cohabit with this kind of EEG feedback because it was oblique to their interests. Curiously, matters were not much different when it came to Lubar's work with ADHD. Lubar was careful to restrict his claims to ADHD, and went out of his way to assert that the training was not thought appropriate in application to anxiety or depression. Hence there was very little common ground with biofeedback, and the thought of tackling the learning curve of EEG feedback for the sake of one indication was not appealing to most biofeedback therapists. They preferred the clients they had to the prospect of a practice filled with unruly ADHD children.

Thus it transpired that the discipline of neurofeedback largely developed independently of traditional biofeedback, and new practitioners joined the field mostly without the benefit of prior exposure to biofeedback, and without the broader insights that such exposure brings. On the other hand, this has allowed neurofeedback to evolve its distinctiveness without the encumbrances of established thinking.

A key distinction is that biofeedback is principally concerned with issues of state regulation. Through the pathway of moderating and stabilizing the response of the autonomic nervous system via measures of peripheral physiology, the larger objective of state regulation could be advanced. When specific clinical conditions were targeted, the benefit was usually derived as a secondary consequence of improved state regulation. Examples in point are asthma, Raynaud's, migraine, torticollis, and bruxism or TMJ. Neurofeedback, by contrast, seemed from the outset to be more specifically directed toward particular conditions: seizures, traumatic brain injury, stroke, Tourette Syndrome, and specific learning disabilities. With regard to ADHD, the focus was on specific issues such as motor control and aspects of executive function more so than on issues of state regulation.

Over time, the generality of effects of neurofeedback became more recognized, and since these broad and diffuse effects could be accomplished with standard protocols, one had to conclude that neurofeedback effects are also mediated by general state regulation, just as in the case of biofeedback. For example, seizure management using reinforcement on the sensorimotor rhythm on the sensorimotor strip was effective largely irrespective of the type of seizure and irrespective of the location of the seizure focus. Neurofeedback offered the possibility of great specificity in approach via both placement and target frequency, but for most purposes such specificity was not essential. Particularly as techniques proliferated in the field, it became apparent that clinical success could be achieved by a variety of approaches. Once again, success with "specific" conditions was secondary to improved "general" state regulation.

Application to Optimal Functioning

When it comes to optimal functioning applications, we are predominantly concerned with issues of state regulation rather than with specific deficits. In pursuit of this objective, we take advantage of the fact that regulatory systems function to so as to regulate each other. Just as dysregulation propagates from one system to another, the reverse is also true in a kind of virtuous circle. This is best regarded in a systems perspective, as illustrated in Figure 2.1. Here the core regulatory arc is that of arousal and affect regulation, which are intimately coupled, and in turn coupled to autonomic regulation and interoception, our awareness of the state of the body. A second regulatory arc is that of executive function, specific cognitive function, working memory, motor planning, and motor function. A third is the regulatory arc modulating the excitability of sensory systems, namely the thalamocortical network and associated circuitry.

Any partitioning of our regulatory regime such as the above can be called into question from a different perspective, and indeed our present purposes are best served by drawing attention to what unifies our regulatory networks, rather than

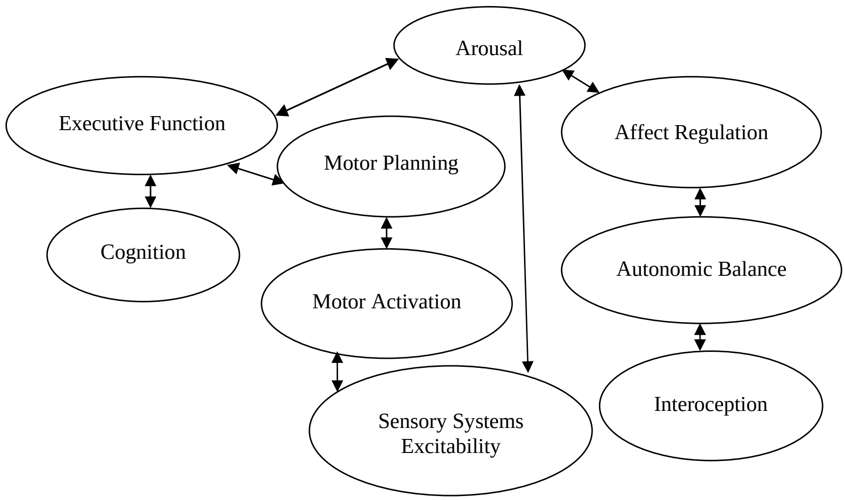


Figure 2.1 The systems perspective.

what differentiates them. There is an overarching requirement for the smooth integration of various regulatory influences throughout the system, and this imposes a global requirement on precise timing regulation of neuronal assemblies. If that quality of regulatory function can be improved, one expects broad and diffuse benefits. By the same token, if such timing integrity is compromised, a kind of internal friction or interference is set up in which our regulatory function degrades incrementally. We then have a soft failure mode, albeit one that may not be readily discernible. It can also be episodic, and it is likely to be state-dependent.

In the realm of optimal functioning, we are mostly concerned with soft failure modes. However, as indicated these may not be identifiable in detail. This calls for a primary strategy of overall functional improvement, to which biofeedback and neurofeedback methods are eminently suitable. To the extent that specific functional shortcomings can be identified, this would be followed by a secondary strategy targeting such deficiencies more directly.

Even in the common enterprise of state regulation, however, the roles of biofeedback and neurofeedback will remain distinct and complementary. Advantages accruing to the standard biofeedback techniques are face validity, simplicity in implementation, and seamless integration with ongoing home practice. In application to optimum performance, the recruitment of the individual into the task of self-regulation should not be a problem – in contrast to the clinical practice environment where this is more of a concern. Advantages accruing to neurofeedback in pursuit of general state regulation include the ability to target specific regulatory subsystems preferentially, as well as the parametric sensitivity to the reward contingencies. That sensitivity makes for a tight feedback loop with the client and with the clinician in order to steer the process in the desired direction. Such steerability is the signal advantage of neurofeedback, in that it allows fine-tuning of the training trajectory for the most rapid approach to the goal.

To be more specific with regard to the respective roles of biofeedback and neurofeedback, it is necessary to describe the task of state regulation more explicitly. In that regard, we are helped by the relatively recent discovery of the default mode network of the brain, in which the resting state of the system is described as a highly active state, organized around a central link between two hubs, one at the anterior cingulate and the other at parietal cortex. Subsidiary axes link lateralized regions in the frontal and the parietal regions with their respective hubs. Some five other "resting state networks" have since been identified that represent tonic activations of particular subsystems.

It is likely that the principal modes of peripheral biofeedback ultimately target the default mode network. The training is done in a low-demand situation, and the movement is toward "calming" states. The operative descriptor is "homeostasis," which incorporates the notion of active balance better than the colloquial term of relaxation. The same likely holds true for neurofeedback as well, when it is used for purposes of state regulation. But in the latter case, we are in a position to engage directly with the frequency-based organization of the default mode and the other resting state networks. In this manner, one is able to target not only tonic arousal of the system but also the activation/relaxation dynamics of the other resting state networks.

There is a natural hierarchy in the frequency-based organization of the EEG in which the lowest frequencies organize (or at least reflect) persistent states, and higher frequencies mediate (or at least index) transient activity. Correspondingly, nearly all of biofeedback involves slowly-varying functions of our physiology. Most of EEG biofeedback to date has involved the mid-range of EEG frequencies of 10–20 Hz. General arousal and specific activation play into these frequencies, and so become readily trainable. But extension of EEG feedback below the usual spectral cutoff of 0.5 Hz has been particularly productive in the enterprise of state regulation.

EEG training in the infra-low frequency region (below 0.1 Hz) most closely resembles Heart Rate Variability (HRV) training in actual practice. In HRV the trainee engages with a dynamic signal that directly reflects the mutual interaction of the sympathetic and parasympathetic arm of the autonomic nervous system. Further supporting the analogy, HRV exhibits the properties of a resonant system, so that the training works best at a frequency optimized to the individual. In EEG training in the infra-low frequency region one engages with the natural fluctuations in network activation (or at least a correlate thereof), and this likewise exhibits the behavior of a resonant system. Hence the training has to be individually optimized.

One consequence of this development is that the key objectives of biofeedback with respect to state regulation can in principle be accomplished with EEG training as well, so a choice between them has to be made on subsidiary grounds. More than likely, however, choices will default in the near term to whatever training mode the clinician prefers by virtue of prior experience. Over the longer term, as more clinicians acquire competences in both domains, one may see a very different division of labor.

Whereas biofeedback methods are relatively mature at this point, neurofeedback still remains very near the starting gate. One can reasonably assume that over time there will be further developments that take advantage of the larger palette available to EEG training. Meanwhile, peripheral physiology will retain one salient advantage: the variables reflect our transient state change exquisitely well, which cannot be said for the EEG. So a natural division of labor will be to use the EEG as a training variable while relying on peripheral physiology for tracking measures.

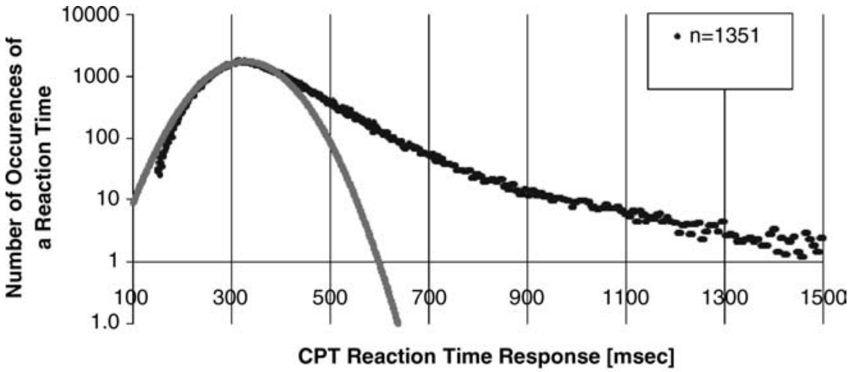
Whereas it is likely that the regulation of baseline states will play the largest role in the training of optimal performance, one must also consider the brain under challenge. The principal burden of the brain – seen as a control system – is to assure its own unconditional stability. This turns out to be quite a challenge, and it is still not understood just how the brain manages it. The brain must be organized to respond rapidly to certain inputs, and yet it must retain stability throughout. These competitive demands place the brain into a bind. And just as the quality of brain function obeys the inverted U-curve of Yerkes and Dodson as a function of activation level, so does brain stability. There are hazards to brain stability at low levels of activation (seizures, migraine, asthma, schizophrenia) and at high levels of activation (panic attacks, cardiac events). Instabilities can manifest on any behaviorally relevant time scale, and those of short duration may randomly disrupt function without being otherwise apparent. These may occur anywhere on the arousal spectrum, and hence present a real but often hidden performance limitation. The existence of these brief excursions into dysfunction must be explicitly tested for. The remedy lies with neurofeedback strategies that target brain stability explicitly.

An example of this kind of instability is the case of a member of a string quartet who was subject to rare, brief episodes of absence seizures. Here the context made such an occurrence very obvious, but that is not always so. There is a much larger universe of more subtle disturbances that may disrupt specific functions without loss of consciousness and without awareness of the deficit.

To understand this phenomenon, one has to look at how the brain organizes its experience of itself. Given the centrality of resting state networks, that constitutes its principal preoccupation. The brain's experience of the present moment is largely encoded spatially, with a temporal coherence of varying duration. The duration is a function of the EEG frequency, with the lower frequencies necessarily showing greater persistence. The brain must navigate almost instantly from one globally organized state to another globally organized state. The brain is therefore perpetually at the edge of stability, in what is referred to as a state of "self-organized criticality." The hazards here are apparent. At times, this process can go awry, and the intended sequencing of brain states can be derailed either transiently or more persistently.

The Role of Assessment

The problem of episodic failure is well illustrated in the standard continuous performance test. The distribution in reaction times for one such test is shown in Figures 2.2 and 2.3 for some 1351 subjects in a narrow age range. In this plot one observes that the distribution in reaction times is "well-behaved" as far out as it was observed, namely 1.5 seconds. The data are a good fit to a straight line beyond the



Note. Data logarithmically compressed vertically. Gaussian fit reveals the long tail.

Figure 2.2 Reaction time data for 1351 subjects.

Gaussian region (Figure 2.3). This indicates a power–law relationship, which is characteristic of "scale-free," fractal, or chaotic behavior. The most reasonable explanation for the occasional long response times is that the brain switched states and eventually returned to the task at hand. The task, meanwhile, was held in working memory. These data make the case that delayed responses in a Go/NoGo paradigm can be described as the long tail of normal, scale-free temporal organization of states. When it is observed that more serious instabilities such as seizures exhibit similar scale-free behavior, then it is tempting to place the entire continuum of instabilities under one conceptual umbrella. Improving self-regulation through neurofeedback then adjusts the overall scaling factor down to lower values, with salutary effects for observed instabilities across all time scales. This is indeed what has been observed over the years.

Finally, there is the issue of soft failures under challenge. Cases in point would include nervous systems that are quite functional in terms of state regulation and overall stability, but still exhibit diminished working memory or specific sensory processing issues. This area has been explored to an extent by Kirt Thornton, and the principal remedy is to train specific network linkages that are not activating properly

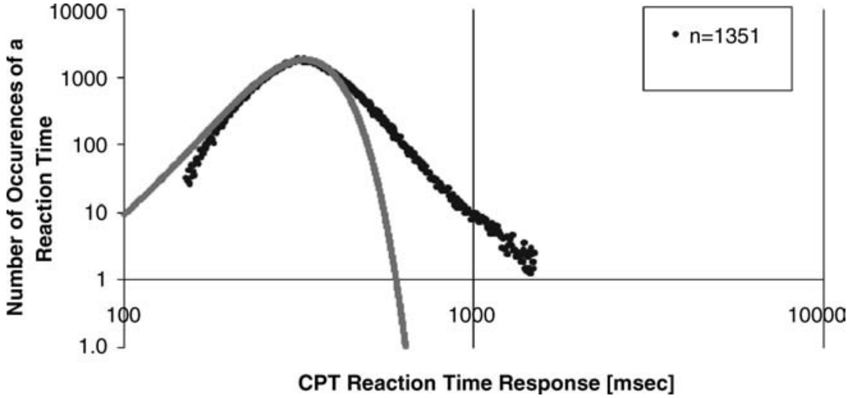


Figure 2.3 Log-log plot of reaction-time data for 1351 subjects.

during testing under challenge. The deficits in these cases typically show up at higher EEG frequencies, in the gamma domain of 40 Hz and up (Thornton and Carmody, 2005).

There is an obvious path forward here through the study of evoked potentials for the primary sensory pathways (auditory, visual, and somatosensory). These can be subjected to Independent Component Analysis (ICA), and complemented with wavelet analysis of transient network activation. By these means we can decompose the brain's response patterns into its functional constituents, from sensory processing to decision-making to motor action. The relationship of one to the other may, however, remain obscure. When coherence is momentarily elevated in a particular linkage in a functional brain, we can interpret this as mediating communication between the two sites. But which way is the flow of information going? Now the direction of information flow in cortex can be further characterized via the determination of "directed coherence," in a manner that has been discussed by David Joffe. Specific network linkages can then be challenged under steady-state conditions with neurofeedback (Joffe, 2008).

Given all of the above, it is likely that in future neurofeedback will take increasing priority in the enhancement of human performance. Peripheral physiology will mainly contribute by way of guiding the process toward success. Traditional biofeedback will play a complementary role in the hand of the professional, but a primary role in ongoing home care.

The Reduction to Practice

Our own clinical work has focused mainly on clinical conditions. However, we have seen a number of clients over the years whose objective was purely the enhancement of their competences. This was particularly true of golfers. Encouraged by an early report of Dan Chartier that he was succeeding in reducing golf handicaps rather substantially with neurofeedback, we took on a local golfer who aspired to the international tour. We got excellent reporting from him on how he saw various aspects of his game impacted by the training. So he got to the point of charting his own course in the training. He did in fact succeed in his goal of touring internationally, and for a number of years he came back for booster sessions.

Another golfer who came to us explained that he had had a motorcycle accident in which his pancreas was so thoroughly lacerated that it had to be removed. We were therefore dealing with a diabetic. After some six sessions, he reported matter-of-factly that his peripheral neuropathy pain had disappeared. We were of course quite delighted, but while we were reveling in our success he remained entirely unmoved. "You have not yet helped my golf game."

We also saw a Hollywood producer who simply wanted to sharpen her mental skills. During the initial interview it became clear that she had a long history of medical issues, many of them still current. In the course of training, all of this had to be taken into account. But none of these issues were of driving concern to this person.

We have also seen a number of Hollywood actors. In one case we saw a famous singer who wished to refurbish her career. On other occasions we saw Hollywood actors who needed help with their performance anxiety, particularly during auditions. In one case a famous actor came in because of the success we were having with his son. He reported the disappearance of his road rage, among other benefits. His wife was grateful.

Over the years we have also seen a number of highly successful businessmen. One came for the "squirrels in his brain" that were making it difficult for him to organize his activities. After one particular session, he walked out of the office, stopped for a moment to consult his brain, and declared that the squirrels were no longer there. Some more sessions were done to consolidate the gains, but success was clearly in hand. A second businessman came for training after seeing what it had done for his son. He definitely benefited, but the degree to which he had improved was not clear to him until he faced a crisis. That crisis was the 1994 Northridge earthquake. He managed to handle all of the emergencies that suddenly confronted him with an equanimity and composure that surprised him greatly. There are also cases that start out with a deficit focus, but end up with a performance focus. A case in point is the story of Sean Casey, the recently retired baseball player. He received training initially for a traumatic brain injury, but then kept going just to enhance and maintain his skills (Casey, 2009).

Finally, there is the observation that in our office setting we offer neurofeedback at any time to any of our staff. It is our observation that everyone on the staff chooses to do neurofeedback at least occasionally. All of this may be considered performance enhancement training because all of the staff is highly functional, but a number of staff members are also chasing one or another symptom.

The above case vignettes make it clear that one cannot realistically separate optimum performance training from work with clinical conditions. The distinction lies solely in the mind of the client. Those who seek out optimum performance training are collectively just as afflicted with "real" clinical syndromes as everyone else. A practice operating under the banner of performance enhancement may even attract cases of Personality Disorder, Tourette's Syndrome, OCD, or alcohol dependency with greater likelihood than a clinically oriented practice.

It is a matter of how clients see themselves. In that regard, of course, they merely share a nearly universal reluctance to see themselves as mentally encumbered. Given that quite understandable attitude, it would be attractive if in the public mind both biofeedback and neurofeedback could be seen more universally in terms of training for functional enhancement rather than for the banishment of discrete disorders. This is in complete accord with the manner in which these methods actually "work." In all instances, the appeal is to what functions in our nervous system. We are only in a position to build on what already works in the brain. Hence dysfunction is banished as a secondary consequence of the enhancement of function. Moreover, it is of no consequence at all as to whether someone lies on one side or another of a diagnostic threshold. Conceptually, this can all fit under the rubric of performance optimization.

Professional Preparation

The foregoing can be read as indicating that we are on the threshold of a simply awesome capability to alter and augment brain function. It can also be read as a cautionary tale about the potential pitfalls for the aspiring clinician. The one message should not be read without also absorbing the other. At the moment there are no experts yet on this new frontier. There is no professional discipline that prepares one for all that needs to be understood. There is no coherent, overarching model that unites the field into a unitary conception. There is no agreement on standards of practice.

Neurofeedback still has all of the characteristics of frontier science. That is not at all a bad thing, except for the fact that professional education has not prepared mental health professionals to fill that role. There is no one better than clinicians themselves to push the boundaries of the field, provided they approach their task with the appropriate humility. This field is not sufficiently mature for a top-down, prescriptive approach to the task. Rather, it must be encountered in the spirit of an observational science, analogous perhaps to a kind of ethology of the human brain. It is the brain's behavior that tells us how it needs to be addressed.

Training for enhanced performance should not come at the cost of something else. It should be an unambiguous positive and not merely a net positive influence. Hence, if adverse consequences of training are encountered along the way, then that represents a categorical imperative to change course. If a given clinical approach does not provide for alternative pathways for moving forward, then it is probably too restrictive for general application. All of the principal clinical approaches to date have their limitations in terms of applicability which must be respected. This means that the established clinician should have a number of different techniques to draw upon, and should be appropriately qualified in each of them. This means exposing oneself to a variety of perspectives that are emerging within the field, and immersing oneself in several over time. The principal technical approaches all have professional training programs on offer.

Principal Neurofeedback Approaches

In the following compilation, the discussion will move from the most general of techniques to the most specific. This is also the recommended hierarchy of approach in a particular case. The first objective in all cases should be toward improved state regulation with respect to tonic arousal, affective states, vigilance, motoric excitability, and reactivity to sensory stimuli. Here the standard biofeedback techniques stand first in line in terms of accessibility, fault tolerance, and cost, and may be all that's needed in straight-forward cases of a nervous system suffering under stress.

The neurofeedback technique that bears the closest kinship to traditional biofeedback in its focus on state regulation is one that we ourselves have developed, namely infra-low frequency training. The basic technique utilizes bipolar placement at key linkages to challenge regulatory mechanisms in a kind of exercise model. The closest analogy to this approach in conventional biofeedback is Heart Rate Variability training. By subtly stressing the system, one can bring about improvement in self-regulatory capacity. The technique works across the entire EEG frequency range to above 40 Hz, but it appears to be most effective for most people at extremely low frequencies. It is likely that the training is affecting the organization of the resting state networks, and that this is a prerequisite for good function under challenge. The most productive linkages appear to be those involving multimodal association areas, in line with the understanding that functional integration is most easily subject to compromise and disruption (Othmer, 2008).

The neurofeedback method that has the strongest association with performance enhancement training is the alpha synchrony training as practiced by Lester Fehmi (Fehmi and Robbins, 2007). A related method has been utilized by Jim Hardt (2007). Four-channel synchrony was featured on the very first computerized neurofeedback instrument, the CapScan system developed by Adam Crane at his American Biotec Corporation. This approach established firmly the observation that a single training protocol could have diffuse and varied effects. It is clear that synchrony training is stronger overall than amplitude-based training. This demonstrates that reinforcement on EEG phase relationships challenges the whole regulatory regime.

This kind of training should play a role in all performance enhancement programs. In addition to the brain training aspect, there is also a strong experiential component. Bad habits are shed; goals are firmed up; addictions are overcome; relationships are refurbished; and traumatic memories are jettisoned. People acquire a steady keel to their life trajectory. They encounter their core self, and may experience a kind of functional integration at that level. Contra-indications here are minimal. The alpha training may not be tolerated by certain migraineurs and sufferers from fibromyalgia, or others showing alpha intrusion into their sleep states.

Next in the hierarchy from generality to specificity is the standard SMR/beta training on the central strip, in which the mid-range of frequencies (nominally 10–20 Hz) is reinforced. The first targets of this kind of training were seizures and ADHD, but clinical targets have proliferated to include the anxiety-depression spectrum and a variety of other conditions. At these frequencies we expect to have an impact on motor function as well as on issues of state regulation. This kind of training is highly suitable for performance enhancement applications, where it already has a long history. There are a few cautions and potential contra-indications, for example with respect to Tourette Syndrome, Asperger's, and OCD, where the higher-frequency training can make things worse.

Next in the generality/specificity hierarchy is standard QEEG-based training, where the inhibit strategy may be informed by indications from the eyes-open and eyes-closed spectral distribution acquired in baseline. If this calls for different locations for the reward and inhibit aspects of the protocol, then a multichannel instrument is required. In this approach, it is not always clear whether a given spectral anomaly actually represents a suitable clinical target, or whether it is perhaps of a compensatory nature. For that reason, one must ultimately judge on the basis of client reporting or on test results to confirm the protocol selection.

Next in the generality/specificity hierarchy is training based on digital EEG analysis under challenge. This approach has been developed largely by Kirt Thornton. Its complexity has no doubt kept the method from broader acceptance. Evoked potential analysis falls into this category as well, and jointly these methods represent the current frontier of the field. Principal reliance here is placed on coherence-based training, where one challenges the phase relationship between two sites directly. When such training is done with respect to goals established in baseline, then this is referred to as Z-score training. Historically Thornton's challenge-based training came first, and it likely benefits from a sounder rationale.

Neurofeedback techniques may also be complemented by stimulation-based methods. These impose specific rhythmic modulations on the cortical electrical potential which serve to challenge neuronal assemblies in their phase relationships. The ROSHI employs episodic pseudo-random frequency-hopping over the EEG band, and thus operates on the principle of stochastic resonance. Some fraction of the time the criteria will happen to be met for a propitious stimulus to one or another of the neuronal assemblies (www.Roshi.com). Alternatively, the stimulus can be derived from the EEG itself, a technique employed by the LENS system (www.ochslabs.com). Standard audio-visual stimulation (AVS) systems are helpful in this application as well.

An old technique that is getting a fresh look is transcranial DC stimulation (tDCS). This can be used to either enhance or diminish activation levels in local regions of cortex simply by application of a modest dc potential to the scalp. The configuration is unipolar, with the other terminal placed on a neutral site away from cortex. The resulting potential alteration extends to within cortex. The method can be used in support of neurofeedback, and it can even be utilized more directly as a training tool via stimulation at certain EEG frequencies to evoke a more specific reaction of the nervous system.

Finally, there are two other methods by which cortical activation can be directly stimulated for improved regulatory function. One simply uses a noncontact, infrared-based measurement of forehead thermal emission, and the other utilizes a near infrared measurement of blood oxygenation. The first is referred to as passive infrared-based training (pIR) and the second as hemoencephalography (HEG). For information on PIR feedback, see www.stopmymigraine.com. For information on HEG feedback, visit www.biocompresearch.org.

Summary and Conclusion

A rationale has been presented for the direct training of brain function to enhance regulatory status broadly for improved overall functionality. A variety of techniques has emerged to achieve such objectives, and studies are accumulating that testify to the broad efficacy of these techniques.

The most obvious target for the application of neurofeedback in the service of performance enhancement lies in the field of education. By intervening early, one has the best chance of redirecting a person's life onto a more propitious trajectory. The downside of brain plasticity, namely the consolidation of dysfunction, will not yet have taken root. The most solid data in support of neurofeedback relate to the remediation of specific cognitive deficits and to improvements in IQ, simply because it is difficult to sustain a placebo hypothesis in such cases. It may be that by focusing on the educational and various other nonclinical applications of neurofeedback we will not only meet a national need but shift attention away from a near-pathological preoccupation with pristine research designs that prevails in the clinical sphere.

Resources

A delightful overview of the historical development of EEG neurofeedback is "A Symphony in the Brain," by *New York Times* writer Jim Robbins (2008). For an introduction to alpha training, Lester Fehmi's book *The Open Focus Brain* is recommended. Most of the available resources address the clinical applications. The most clinically oriented is the book *Biofeedback for the Brain*, by Paul Swingle (2010). For SMR-beta training one can refer to the newly published book *Neurofeedback and State Regulation in ADHD*, by Werner van den Bergh. A broader perspective is taken in the *Handbook of Neurofeedback*, edited by James Evans (2006), and in the textbook *Introduction to Quantitative EEG and Neurofeedback*, edited by Tom Budzynski *et al.* (2008). Finally, there is our own contribution to this work, *The Protocol Guide* (Othmer, 2008).

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Part II

Case Presentations

3

Case 1 – Bad Shot, Good Shot: Neurofeedback for World Champion or Developing Athlete

"Sue" Vietta E. Wilson and Lindsay Shaw

These two case studies will present how a single neurofeedback (Nf) session, combined with biofeedback (Bf), can assist an elite athlete win a world championship and then how this methodology can be used to help a developing athlete learn the skills used by the world champion.

World Champion Archer: Kevin Evans

Background

In 2007 while camping in the Rocky Mountains, the first author met Vladimir Kopecky who had previously coached track and field when she was doing sport psychology (including Bf) with world class sprinters. Vladimir was so excited about his athlete, Kevin Evans a world-class archer preparing for the world championships in Korea, and insisted she use "this neurofeedback stuff" with Kevin. Kevin's history included bow and arrow hunting beginning at the age of 14 with target archery beginning in 2004 After an industrial accident which left Kevin with only one arm, coach Kopecky introduced Kevin into competitive target archery. It took Kevin two years to design, build, and experiment with a trigger release such that when he swallowed the arrow was released. Kevin's Canadian ranking in 2007 was fourth in able-body target shooting and first in Paralympics.

EEG activity and performance

Researchers consider alpha levels as good indicators of attentional processing. Sterman's initial work with animals (Sterman *et al.*, 1969) then top gun pilots

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(Sterman *et al.*, 1994) associated a suppression of 8–10 Hz (part of the alpha band) with increased attention and enhanced 13–15 Hz, sensorimotor rhythm (SMR), with good performance prior to the execution of a difficult task.

In 1984, Hatfield, Landers, and Ray identified that in the time preceding a rifle shot there was a hemispheric shift, where activity in the left hemisphere was reduced prior to shooting. They suggested a reduction in analytic or self-instruction strategies. An early case study with a world calibre rifle shooter (Bird, 1987) used Bf and EEG from O1-T3 to identify good shots from bad shots. Arm muscle tension was lower, facial skin temperature was higher and EEG frequency was lower through the shooting cycle for good shots. The pattern was for the EEG frequency to decrease (from 14 to 12.5 Hz) just prior to a good shot while the frequency went up (14.5–16 Hz) just prior to missed shots. This finding of a reduction in left hemispheric activation in skilled athletes was reported in golf (Crews and Landers, 1993).

Most research associates improved performance with an increase in alpha in the left temporal region (Crews and Landers, 1993; Janelle *et al.*, 2000; Hatfield *et al.*, 1984; Landers *et al.* 1994). However, Salazar *et al.*'s (1990) analyzed differences between best and worst shots in archers and noted an increase in alpha in the left hemisphere was associated with poorer performance. Hillman *et al.* (2000) have generated more supporting evidence for the idea of optimal levels of alpha in their study of executed versus rejected shots in marksmen. In good shots alpha increased only in the left hemisphere but in rejected shots, alpha levels were increased in both the right and left hemispheres. They interpreted this observation as an inappropriate allocation of neuronal resources in the brain in the rejected shots. A clear relationship of alpha to performance has not been established and is likely not formulaic. It may be possible that only a slight increase in alpha is necessary to appropriately quiet the left temporal lobe and produce optimal performance, while too much alpha or too little alpha can interfere with performance, similar to the inverted-U relationship between arousal and performance.

Hatfield, Haufler, and Spalding (2006) presented a comprehensive review of the EEG literature in sport that supports our use of Nf for sport. Interested readers are encouraged to read their extensive analysis of this research. A very simplified interpretation of their conclusions includes: (a) The demands of the sport result in task specific cortical resources being used in an efficient manner, that is, the same amount of work is accomplished but with less cortical activation or effort. This finding recently was confirmed by del Percio *et al.* (2009) who used fMRI and showed that elite athletes have a more efficient brain, less cortical activity, than average individuals and even less skilled athletes; (b) Expert performance is associated with quieting of the left hemisphere, and in some cases, quieting of the right hemisphere; (c) Tasks are performed better if the person learns to become more "automatic" rather than engaging in "thinking"; and (d) Nf can be used to create the changes in the cortical activity that are associated with expert performance.

These findings can provide clinical and research guidance as to how to study and train athletes with Nf. Caution is advised as many factors influence results such as the skill level of the athlete. Shelley-Tremblay, Shugrue and Klein (2006) found increases in beta activity, rather than a reduction, occurred for golfers during more successful putts. Perhaps their results are due to using novice golfers.

Description of the presenting problem

Kevin and Coach Kopecky confirmed that Kevin was a world-calibre archer who tended to miss a shot at some point during the competition which prevented him from winning. Kevin stated the problem as "there are moments when I don't know if to put the bow down." Sometimes when he shot with this indecision, the arrow was off, other times when he put the bow down, retried the shot, he still missed. But Kevin knew what it felt like during these moments of indecision but had not been able to consistently correct the problem.

EEG assessment and training

The first evening Kevin was introduced to Bf and Nf by demonstrating the equipment and having him do trial and error thoughts and feelings (bad shots, good shots, happy, angry, etc.) and then comparing them to the psychophysiological recordings. This was done to create confidence that the equipment was measuring relevant information. Kevin then practiced for less than an hour, making his shoulder tension go up and down (surface electromyography placed on his trapezius), his heart rate up and down (blood volume pulse on thumb), and his emotions (sweat response-electrodermal) go up and down. He then practiced EEG feedback for maintaining a relaxed (raise alpha and SMR) but focused state (lower theta Nf). All measures taken showed no abnormalities or atypical responses.

The next day at Kevin's outdoor archery range, practice began on the 50 m target as smaller errors are more magnified at this distance (the target looks so far away an ATV to get back and forth to the target seemed like a good idea). Problems of working outside, obtaining power, and shade so one can see the screen, were overcome. The Biograph Infiniti with fiber-optic cable was used to connect the EEG with the computer. Cz or the site at the top of head across the motor strip was chosen for monitoring with ear lobes used for the reference and ground electrodes as there is less interference from muscle activity and it is believed to be a summation point for several areas (Jasper, 1958): frontal and midline structures, as well as subcortical structures of the brain (Thompson and Thompson, 2003) (Figure 3.1).

How the assessment proceeded

Impedance was measured and maintained below 10 000 ohms. As Kevin shot, Sue recorded EEG and Vladimir recorded the hit or miss (location) and whether the bow

Figure 3.1 Kevin, coach Kopecky, and Wilson collecting data on outdoor practice range.

was put down. Kevin then indicated whether he felt confident in shooting or had some thoughts of putting the bow down. After a few rounds we compared the EEG for the good shots (bull's eyes) with the bad shots (second ring or worse) and when Kevin put the bow down or felt as if he should put the bow down. The pattern was very clear on the EEG and can be seen in Figure 3.2. On the good shots Kevin

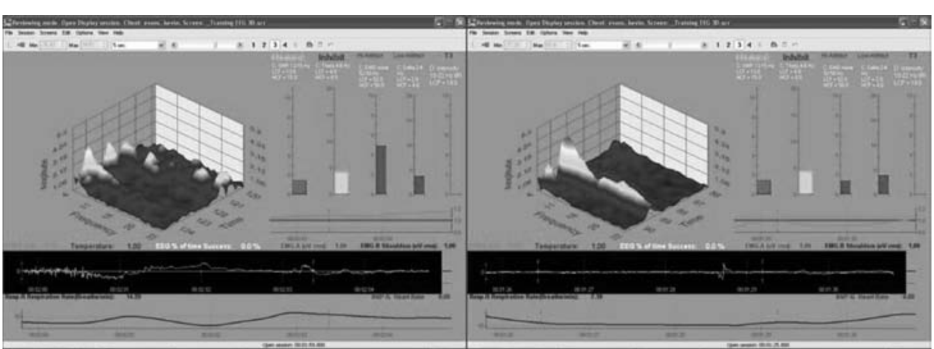

Figure 3.2 Kevin's busy brain (left graph) associated with bad shot and quiet mind (right graph) associated with good shot.

emptied his mind (higher alpha and no beta) before he shot, whereas the bad shots showed brain activity in the higher beta range (22–35 Hz) which is believed to be where rumination, "would have, could have, oh shucks" thoughts are typically reported (Thompson and Thompson, 2003). If he put the bow down and did not clear his mind (beta was still high) before shooting, it was typically a "bad shot."

In both graphs the shot occurs just before the tower on the left side of the graph (which is a movement spike following the release of the arrow). In the graph to the left one can see the brain activity with the little hills in the high beta area (busy brain) on the right side of the graph before Kevin shot and did not hit the bull's eye. In the "good shot" in the right hand graph, Kevin had essentially gone to automatic pilot with no interfering brain activity before the shot. This pattern of quiet mind was evident the entire day for the "good shot."

Having independently recorded the EEG and success of the shots, all three of us agreed that the training should be on "letting go of busy brain." For the remainder of the day, Kevin shot at different distances and when beta was present, Wilson would say "down." He would then practice "letting go" and when Sue saw the beta go down, I would say "go!" The letting go exercises included "ahhasome" (Wilson and Cummings, 1990) which is creating a ten second breath with three counts in, pause on top, let air come out for five seconds and smooth, soften the face, drop the jaw and shoulders, and "let go" thoughts while exhaling. This was practiced on the line. It is Wilson's experience that neutral body oriented activities (breathing or ahhasome) work better for most athletes during the stress of competition than abstract concepts (positive images or statements or meditations). The athlete generally performs better when they are out of the head and into the body (automatic practiced physical sensations). He very quickly learned to put the bow down when there was indecision without a command from me. Kevin went on two weeks later to win the World Championship (Figure 3.3).

Due to a lack of financial resources Bf/Nf training has not continued with Kevin. He does practice maintaining good heart rate and heart rate variability with a portable monitor. The failure to achieve a podium finish at the Olympics suggest that more training under highly stressful conditions would have been advantageous as he lost his concentration in the unfamiliar setting. Kevin states that prior to shooting "I do the 'let go' method." Something I had a hard time doing this at the Paralympics and it did cost me a podium finish. But in 2009 I worked hard on doing it and once again it paid off with the gold at the worlds." He is the first person to successively repeat as World Champion in his category.

Why brief interventions work

What facilitated the value of this very brief intervention must be highlighted. First Kevin was a world-class archer to begin with and is dedicated, and trusting of the coach. The coach was trusting of Wilson as she had previous creditability with other known elite athletes. We would like to note that because both are experienced and of

Figure 3.3 Kevin Evans wins the world championship in Seoul Korea.

world caliber, the identification of the problem and suggestions for training were relevant, specific, and measurable. The verification of the value of the EEG patterns on the archery range then made the data become meaningful and powerful (i.e. without EEG, the athlete nor coach does not truly know the state of the brain before the bad shot/good shot). Lastly, Kevin and Vladimir's passion for the sport and being the best they can be, despite many sacrifices and few tangible rewards, means they are willing to experiment and continue to learn.

Using EEG for a Developing Athlete

Graham Mater is a 16-year-old developing biathlete who is interested in obtaining help in improving his scores. He was ranked in top three junior in air rifle categories and when he moved to the next skill level, the NorAm Cup, he was placed in the top half. Graham is a good academic student, has no known medical or psychological disorders. Several factors are working against Graham's developing as quickly as he would like in biathlon: no snow locally means he needs to drive two hours to ski; his family cannot consistently afford the expense of sending him to high-level training camps and competitions; he does not have the latest equipment (such as guns for indoor laser shooting); and there is no indoor shooting range within reasonable driving distance. In short, he needs to move, (get rich)/receive funding from a national governing body or find extensive creative solutions. Being highly motivated, he roller-skis and practices dry fire shooting and has sought out EEG as one of the solutions to not having all the advantages for becoming a world-class biathlete.

In biathlon competition he typically skis for one loop, approximately 2.5 km, then shoots lying or prone for five consecutive shots, then repeats this ski loop and returns to shoot from a standing position for five shots, and then skis a final loop. If he misses any shot he has to ski additional distances in small loops near the shooting range. To win, he needs to be accurate in shooting but also fast in skiing.

Problem identification

What Graham has identified as a problem is that he is not consistently hitting the target and misfires in a round. There is no consistency even of when he misses and technique does not appear to be the entire problem nor does elevated heart rate (which typically ranges between 130 and 158 beats per minute (bpm) unless his heart rate is well above 160 bpm. He cannot say the problem is that he misses shot X under Y conditions. Athletes and coaches cannot always reliably determine why performance deteriorates and psychophysiology measurement can often locate small subtle differences in the mind and body responses that may distinguish good and bad performance.

Assessment of strengths/weaknesses in EEG

All EEGs had impedance levels below 10 000 ohms using the Biograph Infiniti. The assessment sessions were three minutes of eyes open with both manually and automatic artifacting of the data. Most assessments and trainings were at Cz with one indoor session using T3 and Cz. For the T3 and Cz site comparison, the pattern of shooting was almost identical with only the amplitude being less at Cz. Thus, Cz was used as it is less prone to movement and eye artefacts.

In dry fire shooting in the office where only Graham's assessment of what is a bad shot or a good shot is available, one can see the difference between the two shots. In the first he said it was not a good shot (trigger pull and movement is the tower on the left of the graph in Figure 3.4). Brain activity is visible throughout the record with no shutting down of the brain as was seen in Kevin's when he shot well.

In Figure 3.5 the result is typical of when Graham self-reports a good shot when he is dry firing at a target on a wall outside the door of the office.

There is a very brief period before the shot (just to the left of the screen on the graph) where he has a quiet mind. While it would be desirable to train Graham at the firing range or even better still, outdoors during training on a biathlon course, this is not feasible. Thus, it is necessary to confirm Graham's assessment that dry firing bad and good shots is accurate compared with live firing. We went to the range and

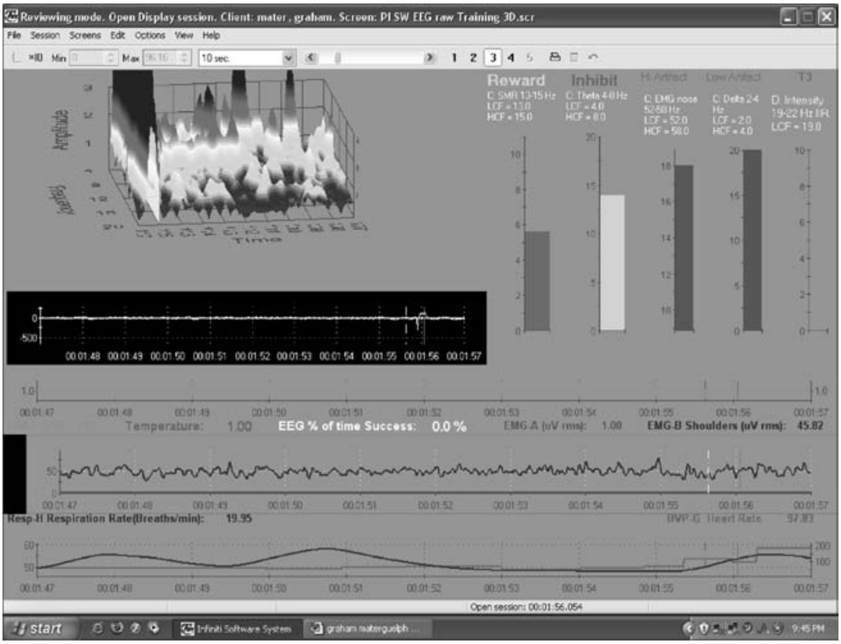

Figure 3.4 Graham reported not shooting well as his mind did not focus. The shot is shown by the big towers to the left of the screen (movement after the trigger pull). The active EEG electrode is at Cz.

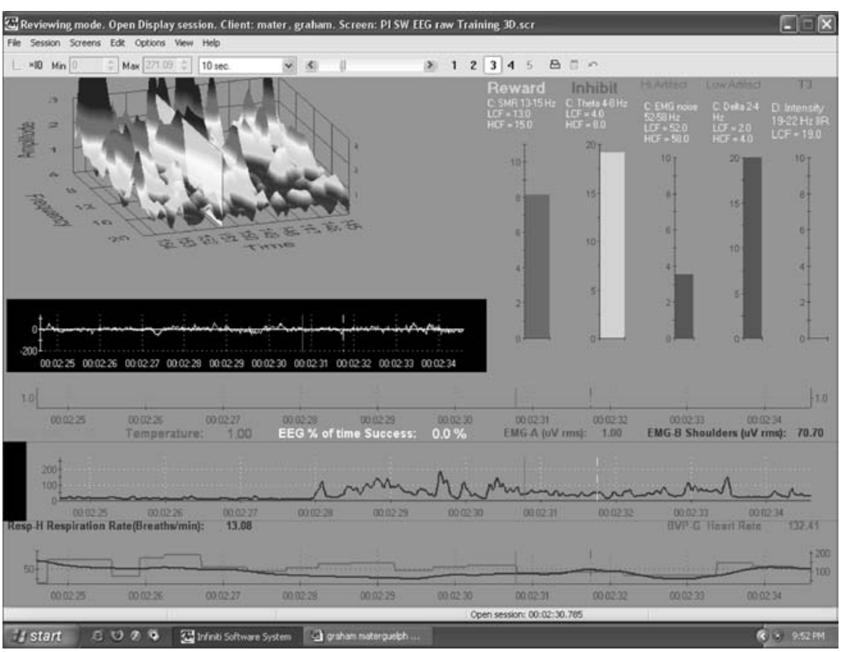

Figure 3.5 This is typical of Graham's EEG when he reports a good shot when he is dry firing.

Figure 3.6 Graham practices "poling" to get his heart rate up to approximate his skiing HR. He then does his target shooting.

measured heart rate and EEG while he practiced shooting. Between his rounds of five shots he imitated (Figure 3.6) the skiing he would be doing by "poling" up and down the range until his heart rate was about 170 bpm, similar to his skiing heart rate before shooting. Figure 3.7 shows the bad and good shots.

Graham assessed this round as bad and correctly identified which three of the five shots were off target. Below Figure 3.7 is an example of his EEG during bad shots in this round. His heart rate during this round was approximately 141 bpm.

In this next round he labeled his shooting as good and correctly identified 5 for 5 on hitting the target. An example of his EEG during this shooting is in Figure 3.8 and his heart rate was approximately 121 bpm.

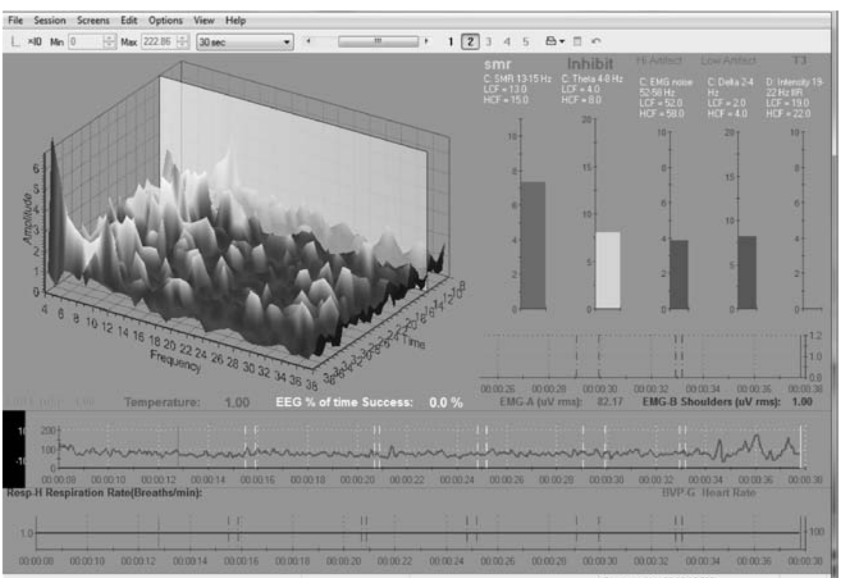

Figure 3.7 Graham made only 2 of 5 shots in this live round of indoor shooting with a heart rate of 141 bpm. Note the amount of high beta (bumps on the right side of the screen) during this episode of shooting.

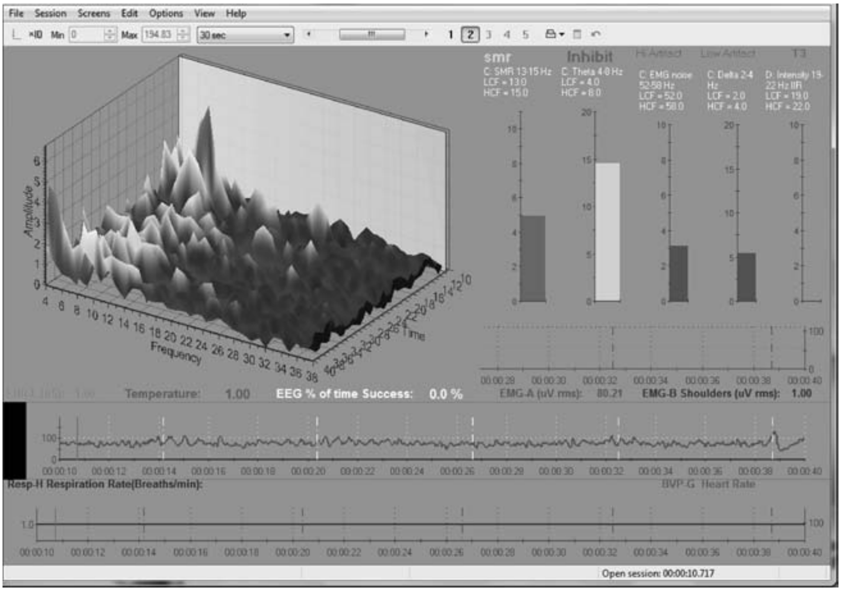

Figure 3.8 Graham had 5 of 5 shots hit the bull's eye, with a heart rate of 121 bpm. Note the relatively quiet beta (18–35 Hz) as shown by no bumps on the right side of the 3D graph.

The indoor target shooting at the range confirmed Graham's self-assessment of good shooting versus bad shooting and was later replicated in outdoor shooting. This suggests that dry firing training in the office using his self-assessment is reasonable. The indoor range shooting also confirmed that he performs better when he shuts down beta for intensity and busy brain waves (19–35 Hz).

One confounding possibility in assessing the EEG between the bad shot (busy brain) and the good shot (less busy brain) was that the heart rate was higher during the bad shooting bout. To assess the impact of heart rate another round of shooting at a higher heart rate was conducted. Even with a heart rate of 155 bpm Graham was able to hit five of five targets and his EEG showed a pattern of a quiet brain. Thus, the range assessment confirmed that when Graham has a bad shot, he has a busy brain and conversely, when he shoots well, he has a quieter mind. Thus the training needed is clear: shut down his busy brain.

EEG training for a focused quiet mind

Graham's EEG training is to first practice the pre-shot state (calm, zone, focused, quiet mind) with a display screen that requires him to first become calm and focused (increase alpha, reduce theta), followed by a screen that requires him getting into the zone (enhance SMR) and reduce intensity and busy brain (reduce beta 18–35 hz). When he has accomplished each of these tasks, the display then requires him to maintain all four states (calm, focused, zone, quiet mind) before the display rewards him. Since there is no shooting screen he typically uses the dart going to the target. He may choose the 3D screen shown above with his task to make a blue lake on the right side with mountains on the left, which mirrors what his "good shots" look like. This screen is Wilson's preference as all frequencies are immediately available and states of wandering mind, movement artefact, drowsy, etc. can be quickly identified. Athletes have preferences for screens so a variety are tried and the athlete chooses the screens for training. The time for training is similar to the sport requirements. In this case, Graham's five-shot shooting cycle takes approximately 20 seconds, thus the training time for each screen is approximately 30 seconds. Changes in the usual amount of time taken to shoot are often clinical markers that need to be investigated. Is the athlete tired, worried, equipment changes, etc?

Then Graham practices dry firing, using his pre-performance state, and reporting whether it was a good shot or a bad shot. He is confident after the fact of whether it was a good/bad shot but not always aware of the mind/body state before the shot (how relaxed, how focused, etc.). The final stage of the session is for him to elevate his heart rate before shooting. Poling as in skiing or wall sits are done until his heart rate is about 170 bpm which then means his shooting heart rate is closer to 140–150 by the time he fires. He then uses his breathing to slow his heart rate while he prepares his gun to fire.

While one objective is to achieve a "stable pre-performance state," the pre-performance state is secondary to creating a "good shot" every time, regardless of how he feels in the pre-performance state. This means teaching Graham how to adjust to differences within his mind and body. An example of this was when we went to a farmer's field and practiced running then shooting but on a day when the winds were ferocious. Graham had ample reasons for his shots to not hit the target as the wind was blowing them off target. But more importantly, this stressful outdoor session showed a significant loss of focus, as seen in higher theta (wandering mind), and more self-talk (18–28 Hz). The ability to show data which suggested that the "external" conditions such as the wind may have been a problem with the bullet, but his "internal" conditions (loss of focus and extensive self-talk) were not due to the wind but rather his internal state. This lead to an understanding that more practice was necessary in more disruptive conditions to work on his controlling his mental states. Consequently we moved back into the office to practice with more distractions. Distractions, such as extraneous movement, target misfired, noise, or talking to him, were included to help him learn to focus when conditions are not ideal. Also, practice has occurred early in the morning and late at night trying to simulate fatigue. The clinician's objectives are twofold: first, give the athlete practice when things are not perfect (and with EEG feedback on the patterns of success or nonsuccess so he knows he is improving in self control) and secondly, to organize the practice such that the athlete gains confidence by successfully mastering the increasing difficult tasks.

Following our training this Fall (2010) Graham's first competition on snow was traveling to the Rockies for the first set of trials for selection for the Canada Winter Games followed by a second set of trials in Lake Placid a week later. These are important competitions as the athletes selected gain the prestige of representing one's province and one's positioning relative to peers, but they also provide funding for training camps and competitions. In the first trials and his first time back on skis this Fall, he surprised everyone by coming in first against his provincial counterparts. After losing the element of surprise of being the new guy on the block, he had to work harder for the next two races in skiing to keep up and he reported his focus was not as good as the first day, but he came in second overall, which was a significant improvement. In the week between competitions, we continued with the focusing, calm session but also spent time on letting go of the mental stress of what others will say and how he might feel (from positive comments that are meant to disrupt his thoughts to those who would attempt to sabotage him). All this was tracked with Bf/Nf and if there were significant anxiety (18–22 Hz) or evaluative/emotional responses (22–32 Hz), Graham practiced emptying the mind and calming the body, then refocusing the mind on the target. In the competitions at Lake Placid Graham reported his shooting was "the best it has ever been, and I shot better under pressure than the other competitors." He did not ski as fast as one other competitor but was able to obtain second place over-all and will be off to pre-paid training camps and then the Winter Games.

Long-term EEG Training for Developing Athletes

The use of the Bf/Nf in Graham's future training is important as he is just beginning to create a "state or zone for ideal performance" and it may take years for it to be "automatic." As noted by Kevin, an athlete needs to be experienced with each new type of competition or have had significant practice in a simulation situation. The degree to which the athlete accomplishes this can be ascertained with equipment. When the logistics of simulation are onerous or impossible, such as being outdoors in winter with Graham, the training can be primarily in the office using films of the past competition and imagery of the future competition. These are interspersed with traditional Bf/EEG training screens for getting into the ideal zone and focusing on the target.

When working with developing athletes the clinical focus is on skill development in controlling the mind and body, and under varying conditions and mental states of the athlete. Biofeedback/neurofeedback is valuable tools to show athletes their progress and develop confidence through competence. The Bf/Nf feedback also works exceptionally well for identifying and tracking emotional responses that might otherwise not be noted.

Summary of Bad Shot, Good Shot

Biofeedback and EEG recordings give us the ability to see the difference between bad shot/good shot, provides opportunities to specifically train the state which produces good shots, and may enhance the speed and consistency of learning. While there may be some commonalities of what works best in good shots (alpha in the left hemisphere), identifying EACH athlete's bad shot/good shot, regardless of sport, confirms exactly what to work on. Most importantly, it provides the athlete and clinician with evidence based feedback on what is working, when it is working, and how well it is working.

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Case 2 – Imagery Assessment and Training with QEEG
What You See Is Not All There Is

"Sue" Vietta E. Wilson and Lindsay Shaw

Introduction

Many years ago coaches and sport psychologist advocated the use of mental imagery almost to the point of exclusion of other sport psychology skills. The mantra of "What you see is what you get" permeated sport psychology research and application. Having spent over 30 years looking at the psychophysiological processes of athletes, the first author found this statement simplistic and misleading and would retort "What you see is not all there is." Fortunately, today's researchers and many clinicians appreciate the complexity of imagery and are developing models, programs and instrumentation that will hopefully improve the quality and the effectiveness of using mental imagery in sport. The first purpose of this chapter is to highlight some of the issues and complexities of current imagery research in cognitive psychology and neuroscience through a representation of the literature. Additionally, while there are many books, research and application articles on imagery to attest to its popularity and complexity, almost all of these are based on self-report. Since no research has been found that has tested the use of NF for training imagery for athletes, our second purpose is to provide guidelines for this training. However, the reader is cautioned to view our suggestions on how quantitative electroencephalography (QEEG) is used in our assessment and mental training paradigm with athletes as preliminary. The investigation and application of NF training for imagery in athletes has just begun.

Imagery Definition and Models

Imagery is a process in which a person can represent (see, feel, smell, etc.) information without having sensory input. Motor imagery has typically been

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defined as a dynamic state during which individuals mentally simulate an action but without executing the action (Jeannerod, 1994). Morris, Spittle, and Watt (2005) suggest that a more comprehensive definition of sport imagery is "the creation or recreation of an experience generated from memorial information, involving quasi-sensorial, quasi-perceptual, and quasi-affective characteristics, that is under the volitional control of the imager and which may occur in the absence of the real stimulus antecedents normally associated with the actual experience" (p. 19).

Imagery has an extensive history in sport with the bulk of the research conducted from the 1980s onward. Reviews suggest that imagery has a positive impact on motor performance but the greatest impact occurs when imagery is combined with actual physical practice (for review see Driskell, Copper, and Moran, 1994; Feltz and Landers, 1983; Greenspan and Feltz, 1989; Morris, Spittle, and Watt, 2005). The research findings are not unanimous on the benefits of imagery and some of the discrepancy comes from important components that are not controlled (Moran, 2009). Recently Milton and colleagues (2008) have asked questions concerning the relationships between imagery, attention, affect regulation and central motor programs. It will take cooperation among cognitive psychology, motor learning and neuroscience researchers who are steeped in sport to ask the right questions and develop models and methods, which will answer the questions.

Models of Imagery

Paivio (1985) presented one of the first models of imagery functions, which delineated both cognitive and motivational functions, at both a general and specific level. For example, mental imagery can influence cognitive specific (skill rehearsal) or cognitive general (strategy rehearsal) as well as motivational specific (goals) or general (self-confidence) processes. There have been modifications (Hall *et al.*, 1998; Martin, 1999) to expand and clarify the model. Munroe *et al.*'s (2000) model included the situation (when, where), interacting with the function (the why of the image) and the content (what). Holmes and Collins's (2001) imagery model PETTLEP added the elements of physical, environment, task, timing, learning, emotion, and perspective to the models. Fournier *et al.* (2008) modified Monroe's model to separate the "what" (modality, perspective, etc.) from the "how" (speed, vividness, etc.) to do imagery. Guillot and Collet (2008) further modified the model by proposing a MIIMS model that identified more clearly the content or the why of imagery into four major categories: (a) motivation, self-confidence and anxiety, (b) motor learning and performance, (c) strategies and problem solving, and (d) injury rehabilitation. They also summarize the literature for what could be called characteristics, or the how, that need to be considered when using imagery. What is apparent to us is the failure to separately identify the WHO is doing the imagery! The person has abilities in attention, memory, personality and cortical functioning that influence his or her ability to do imagery. Neuroscience is just beginning to identify the structures and functions of the brain that will impact the

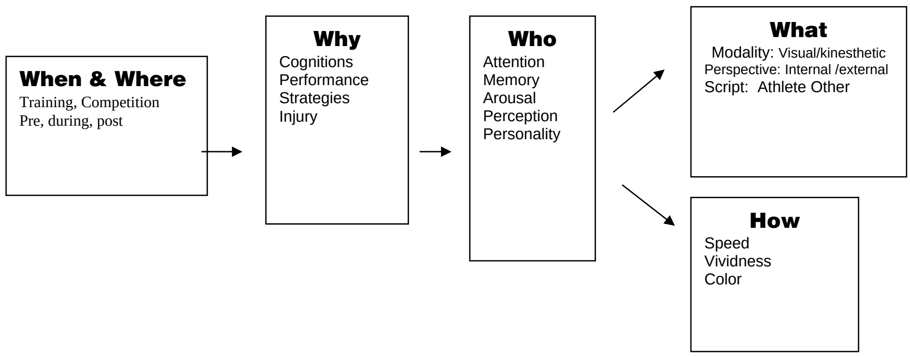


Figure 4.1 Wilson's Amalgamated Training Model of Imagery (WATMI).

choice and use of imagery. Since not one model has included the WHO, we propose Wilson's Amalgamated Training Model of Imagery (Figure 4.1).

Assessment of Imagery

Paper and pencil questionnaires

The most widely report imagery questionnaire is probably the Movement Imagery Questionnaire, developed by Hall, Pongrac, and Buckolz (1985) and revised by Hall and Martin, 1997. It measures visual and kinesthetic movement imagery abilities by having the athlete actually do the movement tasks and then image them and rate them on visual and kinesthetic perspectives. Hall, Rodgers, and Barr (1990) later devised the Imagery Use Inventory which assessed factors such as where the athlete practiced (practice, competition), when (before, during or after event) and asked questions of perspective, vividness and controllability of image.

Hall *et al.* (1998) finally developed the Sports Imagery Questionnaire to assess the motivational and cognitive functions of imagery as proposed by Paivio (1985). Analysis yielded five distinct factors corresponding with the motivational and cognitive functions of imagery. Predictive validity was supported in that greater imagery use was associated with successful performance. Differences between individual and team sport athletes were observed. Watt *et al.* (2004) developed the Sport Imagery Ability Measure (SIAM), which is a 72-item self-report questionnaire that uses six sport-related scenes to examine the dimensions of vividness, control, duration, ease, and speed of generation of the image. Also measured are the visual, auditory, olfactory, gustatory, tactile, and kinesthetic senses as well as the experience of emotion during sport imagery.

The paper and pencil assessment of imagery has a long and successful history of identifying some relevant aspects associated with enhanced performance. The limitation of reliance on self report could be addressed by combing the subjective measures with relevant psychophysiological measures.

Psychophysiological measures

Early attempts to use downstream psychophysiological measures as indicators of imagery effectiveness were first focused on measurement of muscles and can be traced back to Jacobson (1930), who also co-developed the first surface electromyography device (sEMG). He noted a higher muscle response in athletes compared to non-athletes when doing motor imagery. For a review of sEMG as a measure of imagery see Guillot and Collet (2005b). Wilson *et al.* (2010) found that participant-generated imagery scripts produce greater sEMG activity than clinician produced scripts. While the research is conflicting, most studies agree that the relevant muscles are activated during imagery.

The autonomic nervous system (ANS) has also been measured (Papadelis *et al.*, 2007) through the use of sweat response (electro dermal activity – EDA) and peripheral temperature (Vernet-Maury, Robin, and Dittmar, 1995; Deschaumes-Molinaro, Dittmar, and Vernet-Maury, 1991). Guillot and Collet (2005b) summarized the literature that shows EDA responses during the mental imagery of athletes such as swimmers, sprint skaters and shooters. They also note many studies showed respiration rate and heart rate changes associated with mental imagery. One consideration in using ANS measures is that these tend not to preserve the temporal characteristics of the movement. That is, the ANS response may not occur immediately after the event or image. Taking ANS measurements, however, does have the advantage of data collection under practice and competitive conditions.

Neurological measures

There are now several different methods to directly assess the functioning of the brain. Positron emission topography (PET) measures increases or decreases in cerebral blood flow through a radioactive form of oxygen, while functional magnetic resonance imaging (fMRI) measures the changes in magnetic fields in the blood oxygen of the brain. These two methods are superior at identifying the underlying layers and structures of the brain but cannot show the interaction or communication between areas of the brain. The electroencephalogram (EEG) measures the rhythmic electrical firing of the neurons beneath the electrodes on the scalp and yields information on the shape of the electrical wave, its amplitude and speed. 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). The electrical waves have been associated with different pathologies in the brain (e.g. epilepsy) and different mental states (e.g. anxiety, depression, focussing, etc.). Quantitative EEG is the application of mathematical assessment to the waves which allows for statistical comparison. The advantage of QEEG is that it can show activity across time, is less expensive than fMRI, and tracks the communication within and across regions of the brain. It cannot show structure or evaluate lower layers of the brain where the electrical activity is generated. Low resolution electrical tomography assessment (LORETA) is a mathematical process that evaluates surface EEG signals and infers the activity of the underlying structures. A limitation of all brain assessment techniques is that due to the small size of the signals, any movement can eliminate or obscure the underlying brain activity making real time data collection outside of stationary sports close to impossible. Additionally, each technique provides information for either structure or function but not both. The problem of identifying structure and function simultaneously is being addressed with newer methods of combining fMRI with EEG (Yuan *et al.*, 2010). However, the cost, impracticality and lack of application to all sports of this procedure is beyond even that of a typical neuroscientific researcher and will not soon be in the arsenal of usage for sport.

The following is an oversimplified summary of the fMRI studies that compared movement with imagery:

1. Motor imagery and motor execution share common neural circuits, including premotor, supplementary motor, cingulate and parietal cortical areas but are not identical and the activation pattern within shared locations may not be the same.
2. There are more brain structure similarities between movement and kinesthetic imagery than between movement and visual imagery (Carrillo-de-la Pena, Galdo-Averez, and Lastra-Barreira, 2008; Deiber *et al.*, 1998; Guillot *et al.*, 2009; Jackson *et al.*, 2001).

EEG and Imagery

Definitions of electroencephalography

Electroencephalographic (EEG), monitors the electrical activity of the brain with different brainwave patterns being associated with different mental and somatic activities or states such as focused attention, daydreaming, ruminations, or fatigue. It can be used to assess and train athletes in controlling mind/body states and provide a window as to what is occurring during imagery rehearsal.

Another method for recording brainwaves is to repeatedly measure the shape of the wave briefly before and after a specific stimulus (e.g. start gun) and is called event related potential (ERP) recordings. This method allows for more accurate information of what caused the EEG wave to change but is used less often in sport settings probably due to the number of times the stimulus must be presented and its questionable value in open sports. However, Fontani *et al.* (2007) found that (ERPs) recorded during motor imagery and after a motor imagery training period were similar, but not identical, to those recorded during the execution of skilled motor activities. They suggest that studying the variations in amplitude of the ERPs could be used to evaluate the effects of a motor imagery training program.

Regardless of the type of assessment/training used, the nature of the athlete must be considers. For example, volleyball players who performed well under the stress of competition were shown to have a different resting brain state (lower activation in O1-T3) than athletes who did not perform as well (Wilson, Ainsworth, and Bird, 1985). In a new comprehensive study, athletes have shown a different brain EEG pattern than non-athletes or less skilled athletes (Babiloni *et al.*, 2010) at rest. Athletes had a more efficient brain. This was confirmed in Nakata *et al.*'s (2010) review of differences between athletes and non-athletes using different measurement instrumentation. It is also important to know what the athlete is doing when they successfully perform. For a review of EEG when the athlete is performing see Hatfield, Haufler, and Spalding (2006).

Identification of imagery in EEG

Farah and colleagues (1990) review paper on the neurological basis for visual imagery concluded that imagery involves the same visual areas in the occipital, parental and temporal cortex as are involved in actual visual perception. Representative of newer findings from research are Pascual-Marqui (2002). Pfurtscheller and Neuper (1997), Solodkin *et al.* (2004) and Yuan *et al.* (2008) have identified motor imagery as involving many areas of the brain particularly in the primary sensiomotor regions. While similar in many ways, motor imagery is not identical to motor execution (Carrillo-de-la-Pena *et al.*, 2008). In sport Beyer *et al.* (1990) and Weiss, Beyer, and Hansen (1991) reported that imagery conditions are statistically distinguished from baseline for athletes in swimming and wrestling. Stecklow *et al.* (2010) reported EEG differences in mental imagery of the volleyball spike between experts and non-athletes.

Visual versus kinesthetic imagery

In their classic study Davidson and Schwartz (1977) reported that they could distinguish visual from kinesthetic imagery by visual imagery being located in the two occipital sites (back of the head) while the kinesthetic imagery was located in two central sites (motor strip). Careful review of the article shows that this finding was not supported as there were no differences in the central region and the task itself was tactile not a "kinesthetic" task as there was no movement around a joint. Newer research (Neuper *et al.*, 2005) reported that to improve motor-imagery-based brain-computer interface, user training should emphasize kinesthetic imagery as it was found close to the sensorimotor area.

In sport, DeBease (1989) had university softball players imagine running the bases in either visual or kinesthetic modalities while monitoring the four sites noted by Davidson and Schwartz. The only finding was that there was more alpha (8–13 Hz) in occipitals compared to central sites regardless of modality used. Wilson *et al.* (1993) reported using QEEG of 19 sites with experienced swimmers imagining a visual or kinesthetic 100 m swim. The swimmers all had training in imagery, were all presently competing, reported using imagery in swimming and post trial manipulation checks were conducted. In summary, the EEG magnitudes for low alpha (7–9 Hz) for both modalities were attenuated from baseline suggesting that imagery could be detected. Additionally swimmers produced more low-band alpha magnitude during visual than kinesthetic imagery in all sites. This suggests that visual imagery required less neuronal resources to produce than kinesthetic.

Cremades (2002) measured two sites from the temporal, parietal, and occipital regions of golfers and reported greater alpha power during visual imagery compared to kinesthetic imagery. He interpreted these findings as visual imagery being easier to perform. The results are similar to Wilson *et al.* (1993) for swimmers. He also noted that the expert golfers had more alpha than the novice golfers and again the expert–novice difference is similar to Wilson's *et al.* (1993) swimmers. Both are in agreement with a sophisticated fMRI study by Wei and Luo (2010) of professional divers who had better imaging in the relevant sport skills for the kinesthetic modality but there were no differences in nonrelevant simple motor skills.

An investigation of the reliability and validity of using lower and upper alpha as measures of visual and kinesthetic imagery was conducted by Cremeades and Pease (2007). The 30 participants were graduates in a movement science program and no information was given as to their athletic involvement. They report good reliability and validity for the EEG measures as indexes for imagery assessment. Their results suggest that both right and left hemisphere were active in the imagery. Additionally, they reported that those with better visual imagery ability (paper and pencil assessment) had less activation in the occipital region and those reporting better kinesthetic imagery had less activation in the parietal region suggesting a more "efficient" brain. There are limitations to the study in that only two parietal and two occipital sites were assessed; which is puzzling in light of the research showing central sites active during motor acts. While they report using the items from the Movement Imagery Questionnaire, they do not report whether these items were counter-balanced, thus, a presentation order cannot be ruled out. Additional factors such as the use of a predetermined auditory script, and the movements were not sport specific limits the generalizability of the study. They must be commended for being the first to attempt to establish an EEG assessment for movement.

The Future of Imagery Assessment

What is currently possible and feasible in measuring brains during imagery? Dyson, Sepulveda, and Gan (2010) took the traditional QEEG which can assess the function of the brain and applied the LORETA which can infer the structures of the brain to assess simple motor imagery (right and left hand on movements). As expected there was significant activation around the primary somatosensory cortex and they provided both EEG scalp locations and Brodmann areas (structure) locations for motor imagery. This sophistication will be the level necessary to truly understand what is occurring during imagery. It is commercially available, financially feasible but requires a good neuroscience background to administer and interpret. We currently use the LORETA with athletes when there are atypical responses during our normal EEG training.

Further Yuan and colleagues (2010) used both EEG and fMRI systems to understand the covariation of EEG and fMRI responses across multiple task conditions, including motor. This method will potentially pin point the brain's structures and the interrelated neural functioning during imagery. Due to cost and complexity, this method will be reserved for research.

Methodological Issues in Imagery

While the issues of differences in visual and kinesthetic modality have been noted above, there are many other factors which can influence the nature and quality of imagery. Holmes and Collins (2001) suggested that physical, environment, task, timing, learning, emotion and perspective are important contributors to what and how an athlete will image. Milton, Small, and Solodkin's (2008) review includes other factors such as the script and expertise of the athlete or the speed of the image (Louis *et al.*, 2008). Callow and Roberts (2010) discussed the need to account for the order of presentation of the imagery as well as the angle of the image. Holmes and Calmels (2008) provided a critical review of the literature and suggest that imagery may not be as efficacious as reported.

A dissenting view of the use of imagery for sport is present. Dietrich (2008) posited that research using technology has mislead people into thinking that brain responses during motor events and imagery, whether visual or kinesthetic, are the same as execution. He notes that the goal in sport performance is automaticity or implicit control whereas imagery by definition is explicit control. Holmes and Calmels (2008) suggested that observation of events may activate the "mirror neurons" and be a better training method than imagery.

However, decades of research support the use of imagery for performance enhancement but the actual mechanisms that facilitate this improvement may not be the mechanisms of imagery per se. Perhaps they are the motivational, attentional or arousal related mechanisms which are integrated with known factors that are involved in actual movement (lower centers located in the basal ganglia, spinal cord, and peripheral nervous system), the mechanical properties of the body, and the environment in which the movement occurs. Indeed, much has yet to be learned about how imagery can affect the brain and actual sport performance.

It should be obvious by now that "what you see is what you get" is too simplistic and perhaps idealistic. "What you see is not all there is" or the underlying biological/neurological foundations will be extensively investigated for imagery and observation as neuroscientists continue to develop brain computer interfaces for rehabilitation and sport.

Clinical Suggestions

The following comments are based upon conflicting and very limited research that has used motor imagery but not always with athletes. They may be used to guide clinicians in exploring how to assess and train athletes. They also include examples from our experiences working with athletes:

1. Imagery improves motor skill performance.
2. Motor imagery uses similar cortical processes to those in actual movement (Milton, Small, and Solodkin, 2008). They are neither identical nor equivalent. One does not get the same responses or effects from imaging ten minutes of running compared to actually running! EEG can identify whether imagery is occurring.
3. Predetermined scripts that the athlete understands and can do are preferred. The athlete may have a better image if they prepare the script. Be specific if the script is for practice or competition. There are some that feel scripts are detrimental as they take away from the "automatic" nature of the task. Perhaps scripts should be used in the initial stages moving towards skills becoming automatic.
4. Almost all imagery practice is of a positive outcome (skill, arousal, performance, etc.). A negative image may be used in desensitizing from past experience or in preparation of coping in hostile or demanding situations. Included in our work is the outcome of the skill, such as where the ball is to land on the court.
5. Relaxation may help athletes minimize distractions and improve image quality during learning or self-confidence situations. We suggest that most performance imagery should be at the arousal level of the actual practice/competition situation once the athlete has learned how to do imagery. This improves transfer to the sport site.
6. Spatial/temporal relationships of the image should generally match the actual performance. For example a world champion luger reported he could not feel in his imagery unless he was lying in the same position as the sled. However, we found some athletes speed up during certain sections and slow down during others. The purpose of the imagery (strategy, spatial observation on the ice, error detection, etc.) may slow the imagery.
7. There is no consensus as to the frequency and duration of imagery sessions needed for each session. We practice the duration of the skill to match the actual competitive requirements (e.g. a tennis serve is brief, a 1500 m swim may be 16 minutes). Our typical imagery training time is approximately ten minutes during each mental training session. We use EEG to determine when the athlete is not imaging (reduction in pre-established frequency which is usually 7, 8, or 9 Hz) and when the athlete becomes fatigued (extensive theta and delta appear in the recording). We use these opportunities for the athlete to identify when they are not imaging and then have them practice during these mind-wandering or fatigue states in an effort to teach the athlete how to raise arousal to overcome these state.
8. Experts are better at the imagery of skills for which they have been training than are novice athletes. It is projected that they also have better EEG imagery

patterns. We also see changes in EEG patterns as the athletes practice imagery across time.

9. Expert athletes are better able to match their imagery time with actual times, and changing imagery speed in one study resulted in subconscious changes in actual speed (Louis *et al.*, 2008). Factors such as complexity of skill and degree of automaticity may affect speed. For example, international figure-skaters reported no images while doing fast footwork but the time spent on the sequences during imagery matched their competition speed. Additionally they reported excellent imagery in complicated jumps but their speeds during the imagery were slower than actual skill execution. Perhaps they are still using "cues" to initiate the complex skill. The intention may also affect speed. A world champion sprinter was consistently slower on reviewing past championships and explained "Mon, I want to enjoy those." His images of upcoming races matched his current track times. Sometimes we have to change our training times in imagery to match athlete's change in speed as they become more skilled.
10. Performance imagery may be more impactful if done in a competitive environment. If this is not possible, add distractions to the environment to simulate the competitive environment. Our QEEG training is often conducted at the practice court, field, or gym.
11. The characteristics of each individual's imagery, such as visual/kinesthetic, accuracy, and vividness, should be assessed to determine the best imagery program. While self-report inventories are helpful we believe QEEG will be even more valuable in tracking which type of imagery best impacts the athlete. Elite athletes not only have better imagery, they start out with a different ability, which suggests each athlete needs to be trained differently.
12. No consensus exists as to which type of task (open/closed skills) is best with what type of imagery (visual/kinesthetic, etc.). Perhaps external visual imagery may be better for strategy development in open skill sports while internal kinesthetic imagery may be better for closed skill performances like swimming. QEEG can show whether there are brain changes depending on imagery chosen. We find athletes switch or combine imagery type during a single mental rehearsal. World class sprinters reported seeing the start as if from a camera at the side of the track (external third person), run the straight away from internal kinesthetic (feeling the arms pump), see where the opponents are in the last 10 m and then see themselves leaning into the tape again from the side camera position. In imagery ability assessments, visual imagery is reported as being easier to do but recent research suggests there is more motor equivalency with kinesthetic imagery.

Clinical Use of QEEG for the Assessment and Training of Sport Imagery

While there is evidence that imagery affects the EEG, there are no known protocols on how to train imagery while monitoring EEG processed. Until sufficient research on what frequencies and locations are best for training imagery(with athletes), clinicians are encouraged to use all frequency bands and different locations as they learn which protocol matches the strongest image or feeling from the athlete. It is highly recommended that, if possible, the clinician check to see that the image/feeling matches the correct response wanted in the competitive situation.

Before training an athlete in EEG enhanced imagery, an assessment of their ability to do imagery is conducted. Our initial assessment includes a 17-minute Optimal Performance and Health (OP & H) profile (Biofeedback Foundation of Europe) of two muscle sites, heart rate, respiration rate, heart rate variability, temperature, electrodermal response and one or two channels of EEG (Cz and sometimes T3/F7) during cognitive and motor tasks, recovery and positive imagery in eyes open and closed baselines. Only the EEG for the eyes-closed imagery during baseline will be reported as the majority of athletes prefer to image, even while in the sport arena, with their eyes closed. Previous early work used the alpha band of 8–13 Hz for the measurement of imagery while Wilson et al (1993), (Wilson and Gunkleman, 2000 found in their study of swimmers that most imagery occurred within the 7–9 Hz range. Since age and individual differences affect the frequencies of the brain, our new program includes both single Hz bands (from 6–13 Hz) and the traditional 8–13 Hz band. As will be noted in our 3D graphs, we typically observe the imagery across a band width of 4–35 Hz looking for patterns between what the athlete identifies as good imagery vs. less good and how that affects their problem solving, anxiety and busy brain. The location of slightly forward of Cz (FCz) was chosen for training as it represents a summation area (Thompson and Thompson, 2003), was recommended by a world expert (Gunkleman, 2000), and fMRI shows similar activity between kinesthetic imagery and the movement in the pre-motor and motor areas of the cortex. This electrode location is also used for our other mental training functions of calm, focused and quiet mind training and thus, no time is lost to moving electrodes. While athletes report visual being easier to do, they also report more often including both visual and kinesthetic in their sport imagery (Callow and Roberts, 2010).

In Figure 4.2 a sample profile from a person who reports imagery is on the left while the person on the right reported no imagery ability. The bars on the left for each frequency are imagery and the bar for that frequency on the right is from the baseline with eyes closed. During the assessment profile, the athlete completes a one-page sport psychology assessment and is asked about their imagery use in practice and competition. In the OP & H profile, the athlete is asked to choose a recent strong sport image and to rehearse it for 66 seconds. After the assessment the athlete is asked how vivid/strong was the image, how clear, how life like and whether they saw it (visual), felt it (kinesthetic) or any other way they imaged (multimodal). Most athletes report a combination of seeing/feeling. A positive response on the paper and pencil questions, the profile interview and the QEEG suggest the degree of imagery abilities the person possesses. It has been our experience that when athletes report no visual imagery there is documented damage in the visual system of the eye or brain or they have had a trauma (Richardson, 1999).

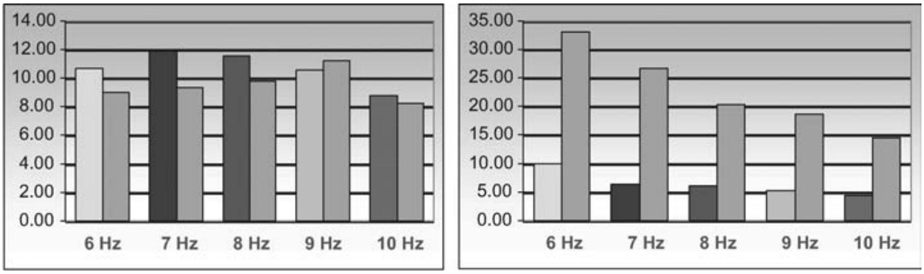


Figure 4.2 The graph on the left is an QEEG at Cz for a person reporting imagery with the imagery bars for each frequency (6–10 Hz) on the left higher than their baseline on the right. The person on the right reports no imagery and there are no responses in the QEEG during the imagery task that are greater than their baseline amplitudes.

In Figure 4.3 is an assessment that is typical of a good level athlete who reports excellent visual and kinesthetic imagery. Note the bars on the right showing amplitude compared to the resting amplitude confirm that he has activated his brain during imagery. While we tend to find 9 Hz more often activated during good reports of visual or combinations of visual/kinesthetic, this is not the case for all athletes.

When this athlete reports their best positive image they generate increases in several frequencies. Wilson *et al.*'s (1993) 19-site EEG study with university/international swimmers suggested there were gender differences in imagery. The gender differences by visual and kinesthetic imagery are shown in Figure 4.4. The male swimmers in the left side of the graph show more relative amplitude 7–9 Hz activity compared to the females in both visual and kinesthetic images of a 100 m swim.

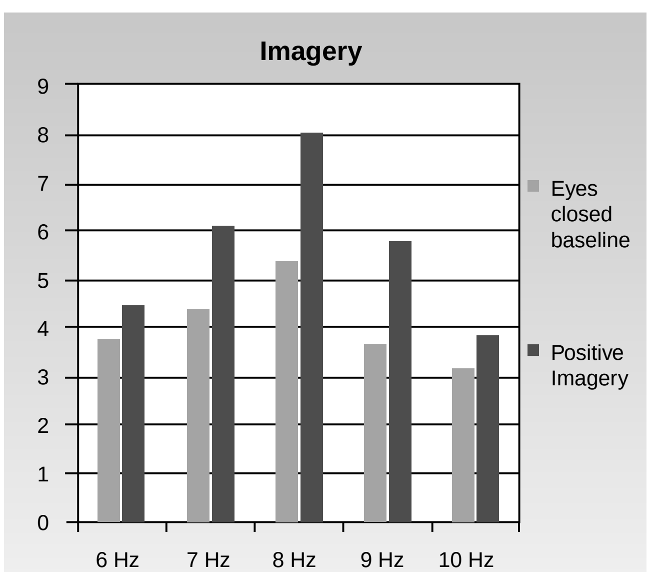
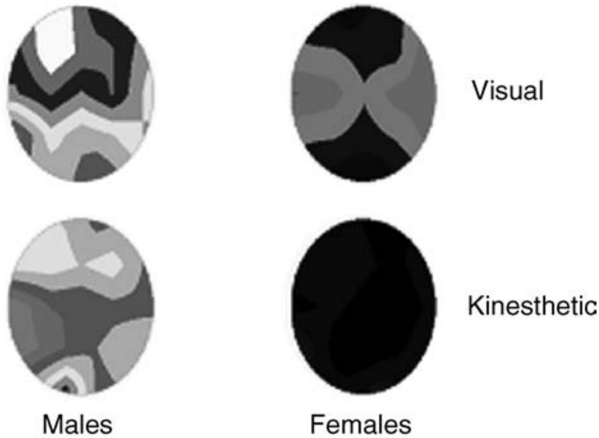


Figure 4.3 An EEG profile of a typical athlete doing sport imagery is seen in the bars to the right which are of a higher amplitude than the eyes closed baseline bars to the left.



Note : Low Alpha (7–9 Hz.)

Figure 4.4 Males on the left side of the graph show more relative power amplitude EEG in 7–9 Hz imagery of a 100 m swim compared to female swimmers on the right side of the graph. Both genders show more relative power in the visual images.

Interestingly, we chose the top five male and five male racers by best times in the actual 100 m race and compared their EEG 7–9 Hz imagery to the next ten fastest swimmers. In Figure 4.5 the faster swimmers (bottom row) had significantly more relative power in 7–9 Hz amplitude in both the visual and kinesthetic conditions compared to slower (but high caliber) swimmers. This is similar to the research reported earlier in this paper that elite athletes are different in how they image. The elite swimmers also had more similar patterns across the kinesthetic and visual imagery, which is similar to what experienced athletes report to us. They use both modalities when they image.

Typical Training Session including Imagery

The use of imagery while having EEG and biofeedback modalities recorded is only one part of our normal training session. Within each session the athlete typically practices how to obtain a calm state, how to focus, how to quiet the busy brain and then imagery is commenced. The modality in which the athlete is most responsive (such as muscle tension or EDR response for anxiety) as well as heart rate variability are tested and trained each session. The imagery session takes about 10 minutes of a 50 minute session. On occasion, an entire session will be devoted to imagery. This is typically with very elite athletes whose sport allows for control of their performance (closed sports such as gymnastics, swimming, track, figure skating, shooting, etc.) and who have shown the ability to control the body. Longer time periods may also be spent on imagery for such as coping with new stressful situations (first time at Nationals), or positive coping imagery when the athlete has not performed well

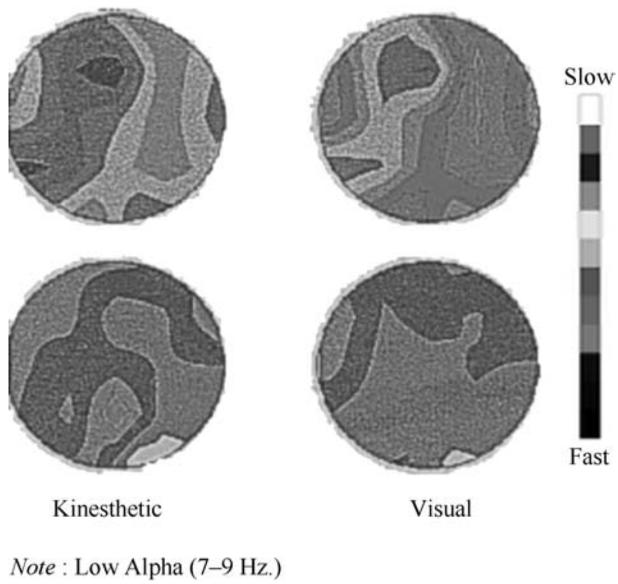


Figure 4.5 Relative alpha power of the fastest 10 male/female swimmers (bottom row) compared to the next fastest swimmers during the imagery of their swim. The faster swimmers had more relative power in the EEG in the 7–9 Hz range for imaging in the visual and kinesthetic mode.

recently and has a lack of confidence. The ability to observe and exert control over the body/mind via Bf/Nf is reassuring to athletes that they have control.

In the imagery portion of each session, a series of sport images are practiced and each one is rated by the athlete on a 10-point scale. First, this allows for a form of validation that the imagery is relevant. After the first series of images, the athlete/clinician looks for a pattern of responses. The confirmation of the trials the athlete reports as being most vivid/clear and real, aligning with an increase in the EEG amplitude, reaffirms to the athlete that they are obtaining valuable "mental training." Second, the clinician can use the session data across time to determine if the athlete is maintaining the intention, focus, and image. Figure 4.6 is an example of a distance swimmer who typically had excellent imagery, which, through practice of about three months with EEG and home practice, indicated he was able to maintain his attention of the swimming image for over 15 minutes. In the second image on the right, there appears to be deterioration in the amplitude with numerous gaps suggesting a loss of attention. He confirmed that he was not training with the same intensity and interest and was not particularly enthused about the upcoming competition. This information may not have been obtained had there not been a documenting change in his typical EEG responses.

In addition to less alpha activity, we typically find the 15–18 Hz range has greater amplitude during poor imagery trials and would suggest that the athlete is thinking/working to obtain the images, compared to a more "automatic" response in the good imagery trial. Additionally, most athletes will show a reduction in the beta

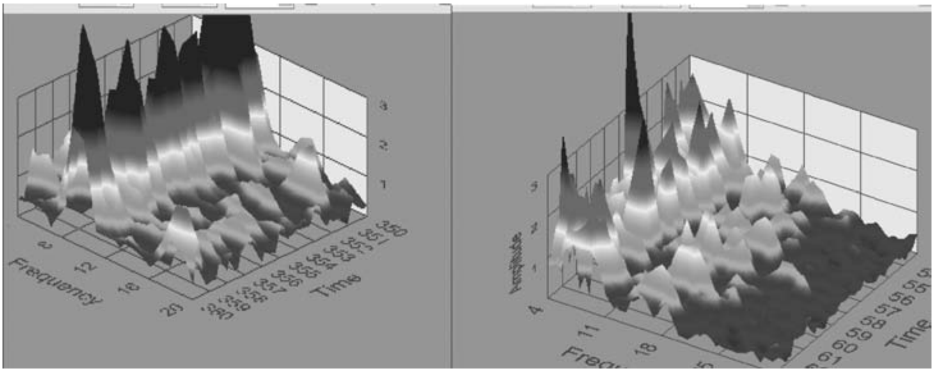


Figure 4.6 On the left is a 3D graph of the swimmer's EEG during imagery of a 1500 m race. The figure on the right is a portion of an EEG recording during imagery of the race where the athlete reported less clear images and loss of attention during the imagery of the race.

activity (18–32 Hz) when they report focusing on their imagery as compared to when they are having intruding thoughts.

When incorporating imagery into a session we try to utilize the principles noted in our Model for Training. A clinical example is to try and make the imagery as similar as possible to the event. Even when athletes are of very high calibre and show consistent patterns of a good imager, such as with Katy, a professional tennis player, who in Figure 4.7 is imaging a serve going in, any small changes in EEG can be seen and support the principles that the clinician is expressing.

Repetition becomes tiresome and motivation can be enhanced when the athlete can see the EEG. By documenting the increases in the 9 Hz amplitude of her EEG across trials she was amazed to see how repetition affected her brain even when she already had shown good initial imagery skills and on court performance, she was more encouraged to practice. Even more powerful were the changes in EEG patterns, shown in Figure 4.8, from Katy creating an image of serving at the practice court to imaging serving against an opponent, and finally an image of serving against a heated rival. This illustrates the importance of environmental context in imagery scripts and we interpret this increase in alpha as a stronger, more powerful image.

Personal involvement seems to play a part in the quality of the EEG pattern. When an athlete has not yet developed imaging skills, or reports not using imagery, we try to either get the sport performance right before the EEG session or we simulate the performance in the office. In the following example, a junior biathlete was asked what he needed to do to keep his skiing at a high level in the competition in the upcoming weekend. He said he needed to focus on keeping his rhythm, poles snapping forward and both legs driving. He confirmed that the hour before he was skiing with excellent technique so he was asked to image this feeling. The lack of activity in the beta range 15–30 Hz during imagery of skiing is shown in left graph of Figure 4.9, which is a significant change from Graham's typical busy brain that is seen on the right during his first attempts at imagery. Probably because the event was

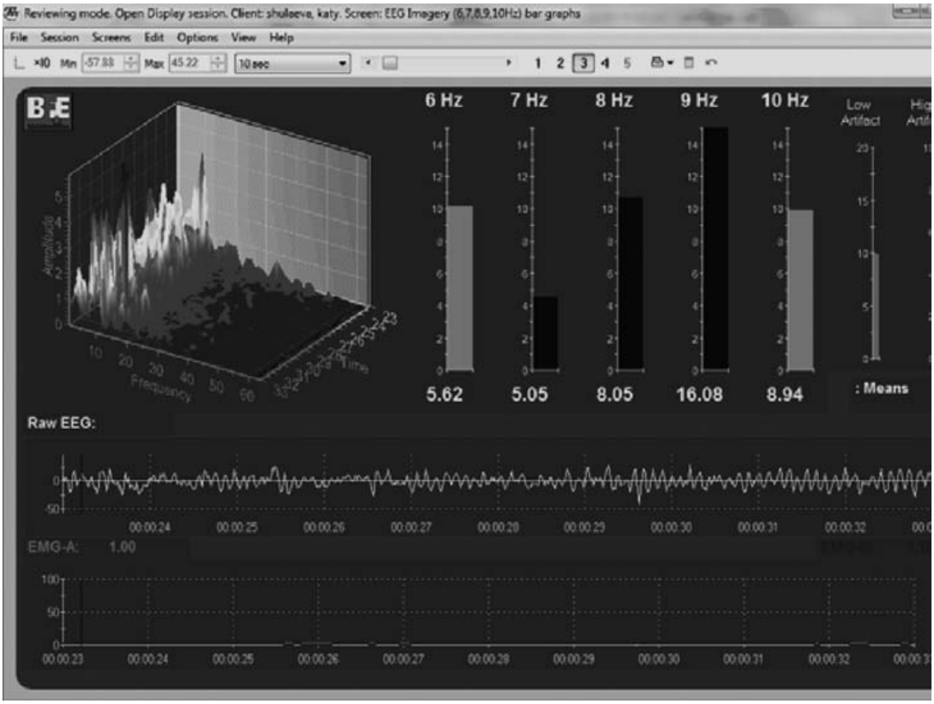


Figure 4.7 Katy is a professional tennis player who has consistently used imagery and shows a repeatable pattern of high 9 Hz activity, along with 7, 8 Hz, and a very quiet mind There is little 15–18 Hz (problem solving) and no 18–30 Hz (anxiety, busy brain) activity.

recent and meaningful, this worked to help him also quiet his mind. We would suggest that imagery can have a similar purpose for athletes before and during competition as a stress management technique.

As he was preparing for a major competition in Lake Placid, a course he knows and likes, he asked if we could do imagery of the beginning of the course which has rolling hills. In Figure 4.10 is a portion of the EEG graphs for uphill and downhill. The first graph is uphill and shows EEG activation in the low alpha band (7–9 Hz) and also activation in the 15–18 Hz, the thinking or problem-solving band, and nothing in high beta. On the second graph for the downhill skiing he has a few seconds of EEG in the imagery band at the beginning and then less alpha activity and very little in the 15–18 Hz as he goes down. He is known for being one of the best downhill biathlete skiers who passes people on the downhill! He reports he gets started and then just "lets his skis go." This may be more typical of the implicit imagery that is automatic. This use of imagery demonstrates several valuable "lessons" that can be delivered to the athlete. The athlete sees that he can shut down his busy brain, but not without a meaningful object on which to focus. Telling a busy brain athlete to relax is probably counterproductive. The EEG of imagery can be objectified, thus, feedback is impersonal and less threatening, and the athlete is encouraged by changes noted on the screen. "I have control.' " Both are powerful psychological messages. The athlete can

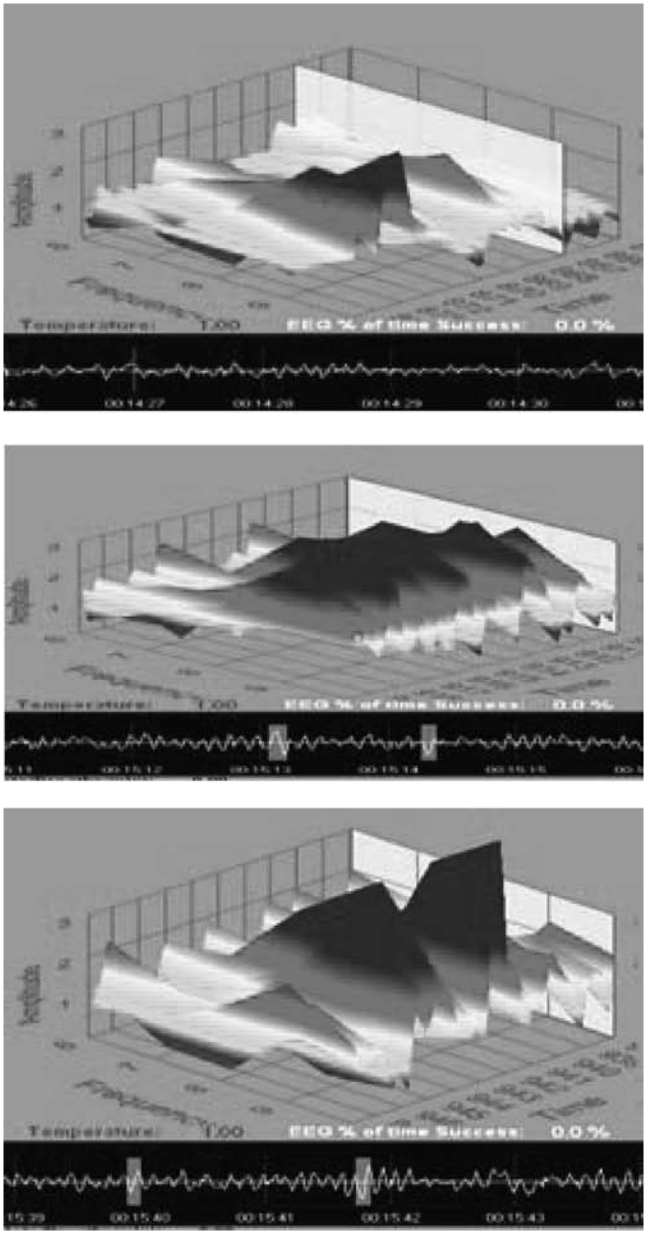


Figure 4.8 A professional tennis players imaging a serve in her home club, followed by a serve against an opponent in a tournament and the last panel is the image of a serve against a heated rival. As she becomes more involved in the image, it can be seen that the amplitude of 9 Hz activity increases.

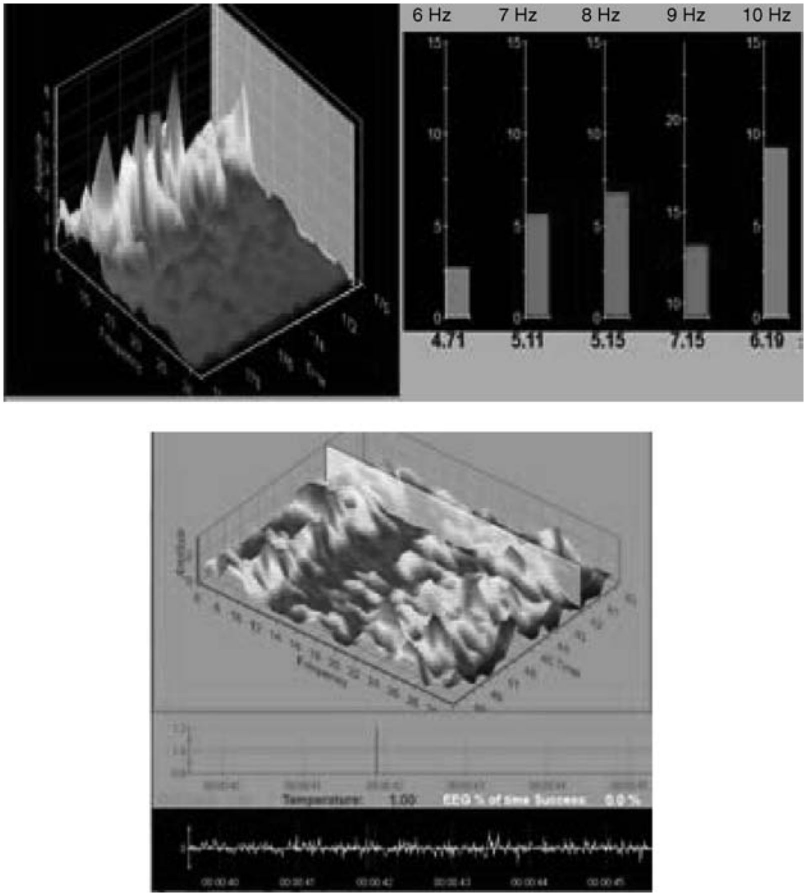


Figure 4.9 Graham imaging his cross-country skiing, which he just completed, resulted in excellent alpha throughout the profile and very little activity in the beta range from 15–32 Hz. This is very unlike his first imagery trial which is shown on the right of the graph.

ask questions or try techniques and receive a "neutral" response: it is not what the clinician thinks/does; it is what the equipment says! Over long time periods "new-ness or novelty" is needed to maintain motivation and athletes ask to practice different images (not always sport). Equally important is the use of EEG when the athlete has a serious interruption in an image or thought. The athlete becomes aware of a previously unknown factor that may impact the performance.

One improvement in our QEEG recordings which we have now incorporated into training sessions is the ability to quickly and simply record the statistics from each portion for comparison. This provides more meaningful information and plotting of progress that will allow us to develop research as well as clinical information. However, we would recommend that pictures of patterns still be presented to the athletes as they are more impactful than merely telling or showing numbers. For example, athletes can identify the gaps on the 3D EEG screen where they may have

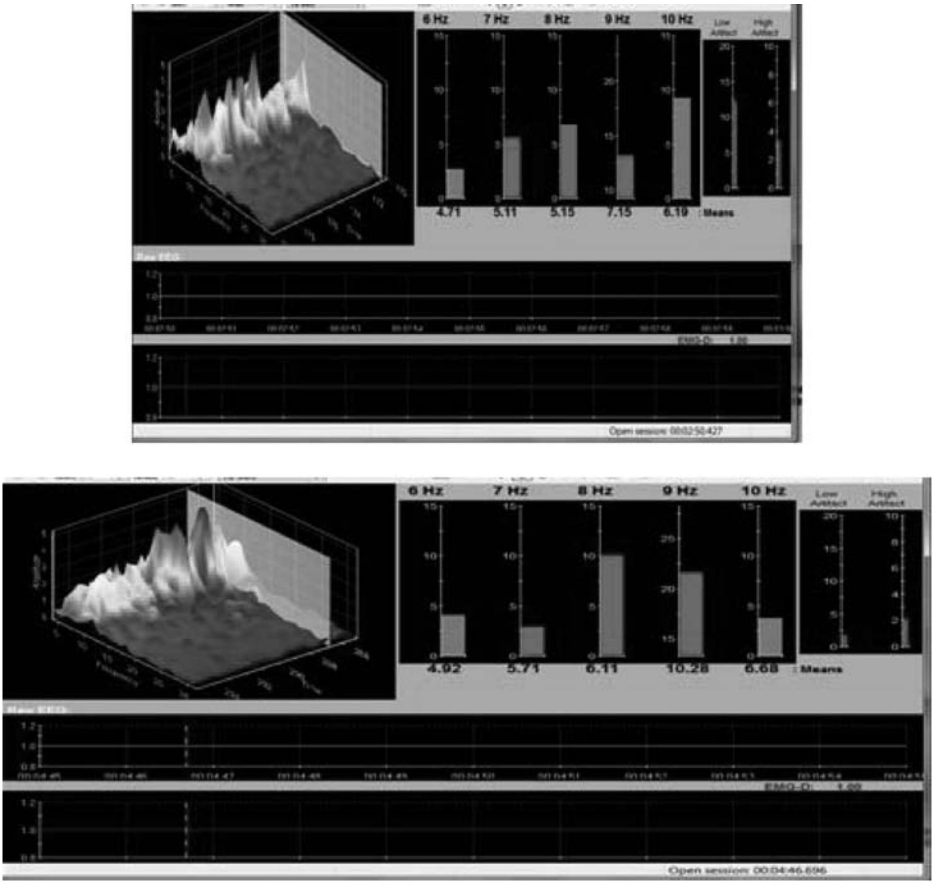


Figure 4.10 The top graph is EEG of Graham's imagery of cross-country skiing uphill at Lake Placid while the bottom is when he skiings downhill. In both cases he has very little beta but he does show more imagery activity and processing (15–18 Hz) during the uphill portions. He reports "letting go" after the top of the hill when he skiis downhill.

lost focus or engaged in excessive thinking for a short period of time. Keeping record of Bf/Nf when the athlete initiates the image and when they are approaching key parts of their performance allows the athlete and clinician to take a close look at what happens in the body and mind, at critical junctions in skill rehearsal. For example, in a 100 m sprinter doing imagery of his last race (he lost), we saw increases in sEMG (muscle tension) and beta involvement (anxiety) at the 80 m mark. This is where he "tied up" and lost the race.

The last case study will be of a young skater becoming the partner of a senior pairs skating team with little time to prepare for Olympic trials. The mental training objectives included skill development for consistency (jumps, throws, spins), communication between the pairs, and mind/body control for the ideal state during stressful competition. Some of the sessions were done individually but many included both partners. The younger member was not as skilled, as noted by self-report and Bf/Nf recordings, in self-regulation, focusing, imagery or performance under the stress of competition. Thus, individual Bf/Nf sessions were conducted for these objectives. For imagery training the first objective was to obtain an ideal pre-competitive state followed by imagery of routines which changed as the skaters skill progressed. Typically the pair watched a video of their latest practice or competition, then talked and imaged fixing the errors and doing a perfect performance. Since they depend on each other for completion of a skill, such as a throw, they needed to interact to coordinate on what was wrong and how to fix the skill before they developed an image of the perfect routine. Next they listened to the music and independently drew on paper, eyes closed, the path of the routine, then compared the routines. Next they drew their routine without the music and the time to completion was noted. Next they listened to the music and imaged the routine. Finally they then practiced imaging their routine without music and compared their times to completion and EEG patterns. The exact sequence is probably not important but what was valuable was changing the requirements for how they interacted and practiced: be it drawing, observing or imaging they found it informative and fun. Timing for completion of the routines and EEG were recorded for most of the sessions. The timing of the imagery became closer to the actual time of the routine with practice. The EEG of imagery showed fewer gaps (loss of attention) and increases in the amplitude of alpha imagery bands and decreases in beta bands. During quiet sections of the routine, their arousal levels dropped in unison as noted by heart rates.

Doing different activites during the session kept all of us motivated and highly interactive. One noteworthy repeatable event was in the routine where fast footwork is done, the alpha frequency dropped to almost nonexistent. Both skaters said they can't image their footwork as it is too fast and too automatic. Perhaps the objective would be for the athletes to show no imagery frequency changes when skills become automatic: Being on "automatic pilot." This would match Dietrich's (2008) comment that skills should be implicit or automatic. Perhaps EEG could be used to monitor this possibility. Our equipment (Thought Technology™) is currently designed to do two EEGs simultaneously as is shown in Figure 4.11, but the athletes feel a DVD should also be on the screen to coordinate their timing. A clinical note would be that doing the mental skills and EEG in pairs allowed for more impactful sessions as they encouraged each other and were encouraged by the changes in Bf/Nf showing increasing similarities between them. Doing traditional mental skills training as well as EEG with imagery and observation in individual and partner sessions must have had some benefit as they capped exceptional progress this year by winning the national championship!

Summary

In summary, we use EEG recording during imagery as an adjunct to explore what the athlete is thinking, seeing or feeling as it relates to the sport performance or personal self-regulation. Just as the microscope identified bacteria so physicians could

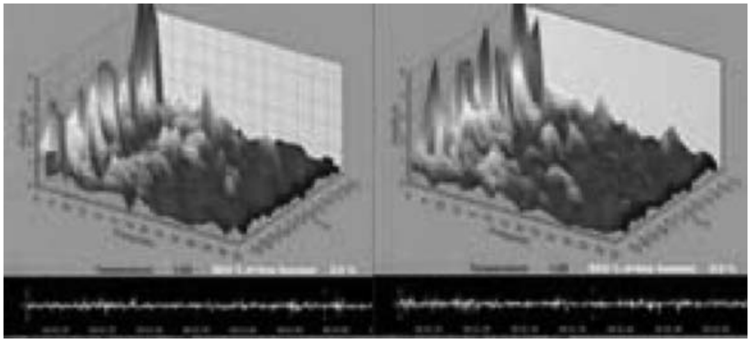


Figure 4.11 This is a 3D graph of the simultaneous EEG of a pair of figure skaters who are imaging their routine. It suggests that future technology may be able to integrate the DVD and synchrony of the pair's EEG.

understand "why" their patients became ill, and then how to best treat them, we believe having the EEG technology to understand "why" imagery works, will help us develop "how" to best teach imagery. The massive investment underway in research into the use of QEEG, fMRI and other brain and automonic nervous system measuring techniques to understand and train the brain for brain computer interface applications (Dyson, Sepulveda, and Gan, 2010) will significantly advance the theory and practical application that can be used in sport application. The scientific investigation and clinical applications into the use of QEEG in imagery training in sport has just begun.

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5

Case 3 – Simultaneous Alpha EEG Enhancing and Frontal's Muscle EMG Decreasing

Biofeedback Training for Musical Peak Performance

Olga M. Bazanova

Introduction

One of the most exciting challenges facing music researchers is to develop ways of assisting performers to meet those demands of music performance that require musicians to process and execute complex musical information with novel artistic insight, technical facility, and a keen awareness of audience expectations efficiently and effectively (Williamon, 2004).

Following Appleman's (1967) research it could be asserted that "musical pedagogy cannot survive as an independent educational entity if the physiological and physical facts, which comprise its core, remain subjects of superficial knowledge" (p. 5). Researchers must constantly interpret scientific facts so that they might become realistic pedagogical tools that may be employed by future teachers of musical performance.

Background Information of Client

The client was a 58-year-old male musical professor who specialized in the violin. For the sake of anonymity I will use the alias "GAV" to refer to him. At the time I started to work with GAV, he was a professor of a prominent musical academy with 35 years of experience. During his teaching experience, GAV developed his own personalized approach to teaching students specializing in musical performance skills. The beneficial results of "GAV's training methods" resulted in more than 40

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Figure 5.1 David Oistrakh.

awards in international competitions. One of his major techniques was to train students to release as many degrees of flexion as possible during musical execution. He claims "Free hands – beautiful sound." So GAV instructs his students "don't touch the violine with squeezed hands." Moreover, in his teaching GAV uses the Bernstein's theory (Bernstein, 1967) which posits that musical performance is a kind of simultaneous cognitive and psychomotor activities, which can be gained by a specific, optimal combination between self-control and relaxation. That is, one can find the balance between the muscles tension engaged in the movement, and the relaxation of muscles that are not required in execution (Bernstein, 1967). GAV is associated with one of the most prominent Russian violin schools and with one of the most well-known violinists, David Oistrakh. In Figure 5.1 Oistrakh is seen playing the violin with relaxed muscles of the hand and face because muscle tension in these areas is not required to perform the violin.

I am a parent of a ten-year-old and she is one of GAV's violin students. I was wondering how I can help my daughter to learn the feeling of simultaneous relaxed arms and self-control, and the pleasure of playing the violin and with accuracy and in tune. At the beginning, GAV asked me not to provide that kind of feedback to my daughter during her practice at home simply because I wasn't experienced enough to recognize the good quality of sound (i.e. the skilled musical performer can receive the feedback sound quality during practice, but for inexperienced beginners it doesn't work). According to his professional experience, GAV recommended that I research the physiological signatures which could reflect and reveal the feeling of simultaneous relaxed and self-controlled performance. As a result I began to study and research this phenomenon and through the years I was able to publish the results of these examinations on the highly skilled musicians utilizing electroencephalogram (EEG) and electromyography (EMG) indices (Bazanova *et al.*, 2003).

From this research we had found that, in the rest condition, EEG and EMG activities are no different in nonmusicians than in musicians. However, we revealed that during musical execution EMG activity of the surface arm muscles which were not recruited in the movement is much lower in skilled musicians than in nonmusicians. In addition, we found that the alpha EEG activity in upper frequency range decreases in nonmusicians but increases in highly skilled musicians. Similar results have been revealed that indicate high-frequency alpha rhythms are predictive of the self-control of motor performance in sportsmen (Babiloni *et al.*, 2008). Therefore, it is now known that by using upper-alpha stimulating biofeedback it is possible to increase psychomotor self-control and cognitive ability (Bazanova *et al.*, 2008, Hanslmayr *et al.*, 2005).

EMG biofeedback has often been applied to train musicians to inhibit unnecessary muscle recruitment and muscular bracing (Basmajian, 1977). For example, subjects are taught to decrease the muscular activity of neck muscles in singers (Pettersen and Westgaard, 2005), the abductor pollicis brevis (a muscle in the hand that serves as an abductor of the thumb) in pianists (Halle, 1993; Zinn and Zinn, 2003), or the M. frontalis in woodwind and string players (Levee *et al.*, 1976), and have all been shown to result in improved musical performance. Moreover, EMG biofeedback is used to inhibit unnecessary muscular activity in the forehead, as well as to decrease the symptoms of various disorders such as tension headaches and anxiety which result from the dysfunction of these muscles. Because it's well known that M. frontalis activity reflects a degree of psycho-emotional tension and upper body muscular activity, practitioners consider EMG biofeedback directed at the M. frontalis as a therapeutic technique for all kinds of stress-related disorders (Canter, 1975; Stoyva and Budzynski, 1974). Relaxation techniques directed at the removing tension for the forehead, jaw, and upper shoulders can alleviate many stress-related problems. I personally have observed that during musical performance forehead EMG activity increases in amateur musicians and decreases in highly skilled musicians. When utilizing EEG during these types of investigations with EMG in the frontal muscular regions it is important to consider the EMG contamination of the EEG signals, which is one of the biggest problems with electrical brain activity investigations (Goncharova *et al.*, 2003). Moreover, the mitigation of EMG by filtering EEG signal is unsatisfactory (Freeman *et al.*, 2003). The only one way to diminish the influence of this artifact is to account for those EEG periods when EMG amplitude is minimal.

The reciprocal interrelation between EEG alpha power and frontal EMG (Halliday *et al.*, 1998) gives us the framework from which we can create the simultaneous alpha EEG stimulating and frontal muscle decreasing biofeedback training technique (alpha-EEG/EMG BFB) (Bazanova and Shtark, 2007). We initially used alpha-EEG/EMG BFB for peak performance achievement training musicians, as well as for stage-fright prevention (Bazanova *et al.*, 2009). My client, GAV, tested the alpha-EEG/EMG BFB technique usefulness on himself prior to recommending it for use on his own students. His overall and general consensus was that value of biofeedback will result in the feeling of "awareness of musical execution with ease and comfort," which is a critical element for all musical performers.

Description of the Presenting Problem

GAV participated in an unusual home-construction job which required some drilling. In the days following the work he started to feel numbness and tingling on the left palmar surface and the pain would then radiate up to his left shoulder. He apparently strained his hand while drilling, which caused the pain. Additionally, to complicate the issue, his regimen at the musical academy was more stressful than usual as he was dealing with the pressure of training two students for a high-level international competition. During this time GAV left these symptoms untreated. As a result, the symptoms became worse, affecting his wrist, hand, and finger movement during violin play. As his students' competition commenced, GAV was getting increasingly stressed and anxious, which created the onset of tension-headache symptoms along with the pain in his hand. So GAV asked me to provide a few sessions of the alpha-EEG/EMG BFB to address his ailments and bring him back to the state of "awareness of musical execution with ease and comfort," and to decrease pain symptoms.

Assessment and Diagnosis

The aim of the training was to "attain a pain-free state" at which achieving musical performance and movement would be complimented with feelings of "ease and comfort." In order to implement the alpha-EEG/EMG BFB intervention, I utilized the Wingate five-step approach (Blumenstein *et al.*, 2002). The protocol is adaptable and allowed for adjustments based on the circumstances, context, and the specific needs of the client (see Figure 5.2).

GAV was taking his summer vacation after completing his students' international violin competition, and was devoting his time to our BFB training. I knew his time was valuable and limited. I had to make the most of our time together and understand that his participation was voluntary and realize that at any time he could stop coming to see me for assistance. Therefore, I designed the first four steps of the protocol to be implemented over a four-week period, which lead up to the new academic year. This gave us enough time to work through all the relevant steps

Step1 **Introduction to BFB**	Step 2 **Identification**	Step 3 **Simulation**	Step 4 **Transformation**	Step 5 **Realization**
Adapting to and learning various self-regulation techniques and its impact on pain intensity, hand execution, motivational competence and EEG features of musical performance.	Identifying and strengthening the alpha-EEG/EMG BFB response protocol.	Proceeding mental practice imaging learned through BFB movement strategies.	Proceeding self-practice learned through BFB movement strategies.	Obtaining optimal regulation in real-world scenarios.

Figure 5.2 Wingate Five-step Approach.

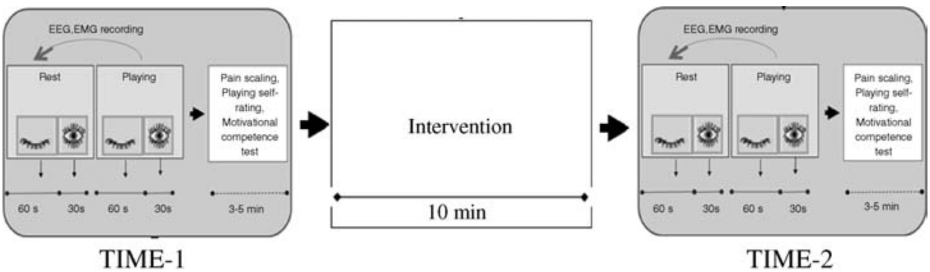


Figure 5.3 Pre-inventory (Time-1) and the post-inventory (Time-2) periods.

without rushing and allowed GAV time to get ready to teach for the upcoming academic session.

At every step in the pre-inventory (Time-1) and the post-inventory (Time-2) periods, GAV was administered tests for rating his pain intensity, musical performance quality, and self-motivation (see Figure 5.3). I recorded EEG and EMG in the resting condition with eyes closed and then with his eyes open. I then tested him during performance for different short virtuous musical pieces of the same difficulty level of his own choice. This lasted for approximately 1–2 minutes in duration with his eyes closed and then with his eyes open, which allowed me to measure a musical execution optimality coefficient.

I utilized the short and easy visual Wong Baker Pain Scale, which is useful for people when English is not their primary language (Wong and Baker, 1988). GAV was able to accurately indicate his level of pain using this scale. I also wanted to determine how GAV's self-confidence was influencing the quality of his performance; I therefore asked him to self-rate his short (1–2 mins) virtuosic pieces before and after phase of the intervention. Musical performance was self-rated for "technique," "rhythm," "musicality," "intonation," "quality of sound" and "creativity." These are the criteria adopted by international competitions and auditions and based on a scale of 1–10 (Kraus, 1982, 1983). Because mental practice and concentration is one of the most important factors that must be a part of musical practice, I implemented Rheinberg *et al.*'s (2003) model of motivational competence test. Rheinberg defined perceived self-motivation as the ability to mentally practice and concentrate at one's own will.

EEG and surface EMG recordings were administered using a BOSLAB computer-based system with an EEG and EMG amplifier (Novosibirsk, Russia). EEG and EMG signals were recorded under, first, one-minute resting eyes closed (EC) and 30 s eyes open (EO) conditions, then 1 min EC and 30 s EO while playing music in the appropriate musical performance position. The cables were fixed on the head to stave off movement artifact.

EEG was recorded from Pz site according to the standard 10–20 system with a reference sensor place on the right ear and a ground sensor on the left (see Figure 5.4). The posterior parietal site was chosen because this cortex area is involved in the integration of sensory and motor processing, as well as the combination of tactile and proprioceptive information with other sensory modalities (Hari and Forss, 1999).

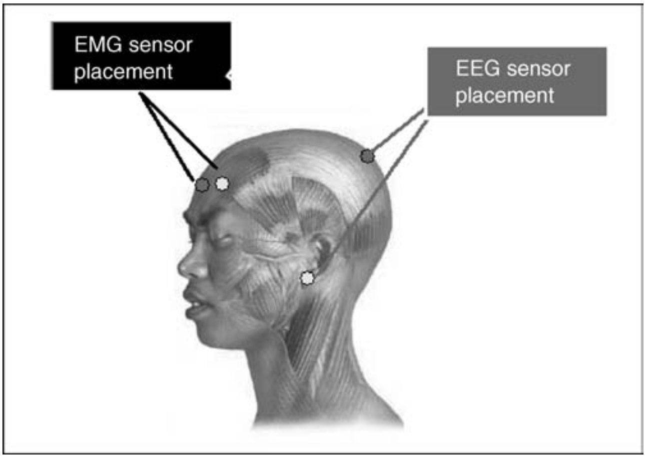


Figure 5.4 EEG sensor placement.

Our previous "test–retest" examination of the individual alpha indices for reliability and variability revealed that individual alpha-peak amplitude and frequency, alpha-band width and alpha amplitude attenuation in response to EO are the most reliable and the least variable in posterior cortex area (Bazanova *et al.*, 2008). Moreover it's well known that the level of these alpha indices in the posterior cortex areas is higher than in fronto-central or temporal areas (Nunez *et al.*, 2001; Thatcher, 1998).

After analogue filtering (0.5–70 Hz, 12 db/octave), the EEG data were then digitized with a sampling frequency of 256 Hz. The high-pass filter typically filters out slow artifact, such as electrogalvanic signals and movement artifact, whereas the low-pass filter filters out high-frequency artifacts, such as EMG signals. An additional notch filter was used to remove artifact caused by electrical power lines (50 Hz). The impedance was maintained below 5 kΩ. Once the visual artifact removal procedure was finished, amplitude power was calculated for each two-second period over a frequency range of 0.5 to 30 Hz. The power spectrum calculation was performed using the Fast Fourier Transform Algorithm (Cooley and Tukey, 1965). The row of EEG files were converted into text format and stored for off-line analysis in WinEEG program (Mitsar, St Peterburg, Russia).

The silver/silver chloride bipolar electrodes with an active diameter of 6 mm and a center-to-center distance of 20 mm were used for recording the surface EMG. The EMG signals were bandpass filtered at 20–800 Hz and sampled at 1600 Hz. They were, thereafter, A/D converted, and the root mean-square value (IEMG) was calculated and transmitted at 10 Hz on a serial interface to a computer (Merletti, 1999).

Alpha Activity EEG Analysis

On the basis of Möcks and Gasser (1984) regarding functional test EEG epochs and optimal lengths, I used 20 seconds eyes open in reference to 20 seconds of eyes closed

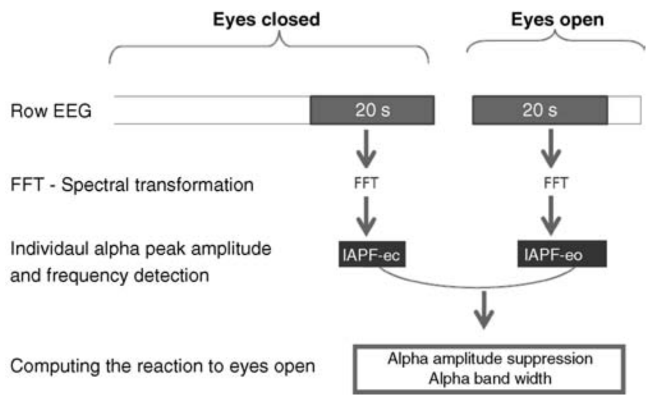


Figure 5.5 20 s EEG segments with eyes open and eyes closed.

EEG intervals. I limited the EEG analyses to changes of power, frequency and eyes open desynchronization only in individual alpha band for two reasons: (1) the delta, theta and beta bands amplitudes are subject to significant artifact- muscle activity for beta; eye movements, respiration, skin sweating, and movement from 0 to 4 Hz for delta and theta (Nunez, Wingeier, and Silberstein, 2001; Thatcher, 1998), and (2) our prior studies have reported significant EEG changes only in alpha band during musical performance. After the visual artifact rejection, 20 s EEG segments (taken as ten 2-second epochs) were analyzed for individual alpha activity indices through the steps seen in Figure 5.5.

The alpha peak frequency (IAPF) and amplitude (A) were measured by the standard approach (Angelakis *et al.*, 2004). It was shown that the individual alpha peak frequency in the eyes closed resting condition indicates individual differences (Anokhin *et al.*, 2006; Vogel *et al.*, 1982) and reflects the aggregated resource of alpha generation as a function of cognitive involvement into a specific task (Feshchenko, Reinsel, and Veselis, 2001; Hooper 2005; Klimesch, Sauseng, and Hanslmayr, 2003). The individuals with IAPF $\geq$10 Hz usually are more fluent and successful in cognitive and motor task performance than those who have an IAPF lower than 10 Hz (Bazanova and Aftanas, 2008; Klimesch, Schimke, and Pfurtscheller, 1993; Bazanova and Mernaya, 2007). In other words, if a shift is observed in alpha frequency, then it could be due to the treatment. For instance, Hanslmayr *et al.* (2005) showed that increasing power for the individual upper alpha (IAPF+2 Hz) through the use of neurofeedback could improve cognitive performance.

The individual alpha bandwidth (IABW) and alpha attenuation coefficient (AAC) were obtained by comparing traces with the eyes closed and open by methods described previously (Bazanova and Aftanas, 2008). Previously differences in arousal levels (measured by electrodermal conductivity) were linked to differences in EEG alpha amplitude (Barry *et al.*, 2004). Barry observed that increases in skin conductance level were associated with global reductions in EEG alpha amplitude across the scalp, with no topographic changes evident. In line with Barry's (2004) findings, I utilized the AAC as a marker of activation intensity (Barry *et al.*, 2007). The EEG-fMRI coupling investigations demonstrated that the spontaneous decreasing alpha amplitude was associated with increases in cognitive activity (Laufs *et al.*, 2003). It appears that, the individual alpha frequency range could vary based on brain activation requirements, which could characterize top-down control. Moreover, the individual alpha band width has been found to positively correlate with flexibility in nonverbal and creative-task performance (Bazanova and Aftanas, 2008).

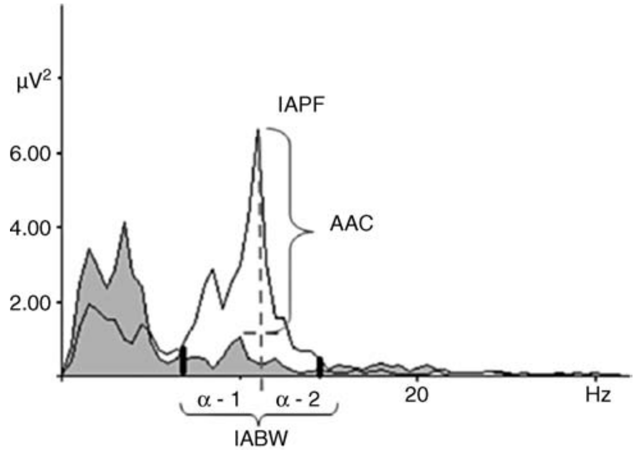
The alpha band boundary frequencies were identified as frequencies where spectral alpha amplitude is decreasing, but theta or beta amplitudes increase in response to eyes open. The IAPF for Pz site in the eyes closed condition was used as an anchor point or as the cut-off frequency between the lower and upper alpha bands (alpha-1 and alpha-2).

Intervention

Step 1 – Introduction to BFB: Adapting to and learning various self-regulation techniques

Step 1 was conducted over five sessions and lasted no more than one half hour each. I explained to GAV that the aim of this step was to observe his pain intensity, rating of musical execution, motivational competence, EEG and EMG activity before and after exposure, and to recommend a relaxation strategy. Because the biofeedback screen was designed to display the forehead muscles IEMG and EEG power in IAPF+2 Hz (see Figure 5.6), GAV could learn how these indices changed during the intervention. I explained that supplying traditional strategies could bring him to achieve the simultaneous upper alpha-power increase and IEMG decrease. Because the occurrence of the "alpha experience" can be accounted for by complex results of interrelated factors (Plotkin, 1979), I proposed to use only those self-regulating techniques which were known to increase alpha activity. Unfortunately, there are only a few examinations which demonstrate specific regulation techniques that impact the upper-alpha power (Caldwell *et al.*, 2003; Fumoto *et al.*, 2004), and no conclusions about any strategy which leads to an increase in activity in the individual upper-alpha range. Therefore, I proposed the use of the following strategies: "Warming hands" (Nozawa and Tacano, 2009), "Postural control" (Caldwell *et al.*, 2003), "Breathing" (Fumoto *et al.*, 2004), and "Frontal muscle relaxation" (Canter, 1975). Moreover, these strategies were used by GAV in his own teaching practice as general recommendations for achieving the "ease and comfort in musical execution" by his students. As a result, I expected that the musical execution optimality coefficient would increase.

Each regulation strategy was used for one session, which lasted 30 min with assessment rest and musical execution conditions before and after practice. Instructions were given before the first resting period and then instructions for the main features of the next regulation technique were presented.



Note: The ratio of the upper alpha (IAPF + 2 Hz) power mean (AP) change to IEMG mean change during musical execution was named as the Musical Execution Optimality Coefficient (MEOC) and computed according to the formula: [100 – 100*AP rest/AP execution] / [100 – 100*IEMG rest/IEMG execution].

Figure 5.6 The identifying individual alpha activity indices: IAPF – individual alpha peak frequency; AAC – alpha attenuation coefficient; IABW – individual alpha band width for eyes open condition. The white color under the spectral curve indicates the spectral field for the eyes closed condition (grey color indicates eyes open).

In the first session, GAV was introduced and connected to the EEG and EMG channels, and allowed an "adaptation period" to become accustomed to the environment and equipment. I utilized channels *EEG and EMG* on the Boslab for the EEG and IEMG signal and placed the EEG sensors on the Pz and EMG sensors on his forehead (see Figure 5.4). The treatment took place in a small office that included a couch, desk, and biofeedback equipment. The ambient temperature in the office was regulated at a constant to ensure no interference with the modalities. There were a small desk, computer, equipment, and usual orchestras chair for GAV to sit in front of the monitor. A desktop computer equipped with BOSLAB + software was used to manage the data collection. I utilized a dual-monitor setup and positioned my monitor in a way that I could view the same screen that GAV would see without having to distract his concentration by viewing over his shoulder or "crowding" his space.

With the electrodes in place, GAV was taught the different regulation techniques by increasing the upper-alpha power and decreasing frontal-EMG tension. During every session, GAV viewed the biofeedback screen to see how these different techniques were affecting his EEG and EMG activity. Musical performance, pain intensity and motivational competence were assessed during Time-1 and Time-2 as seen in Figure 5.3. I also asked GAV to apply the simplest musical execution technique using his left hand with only the fingers movements on the neck of the violin. Based on the findings from these initial assessments, I understood the importance of developing a biofeedback-based intervention designed specifically for

GAV. The primary was to teach GAV how to regulate his affective states cope with the pain in his hand and ultimately improve his musical performance.

During the first session, GAV reported an extreme high level of pain symptoms, particularly when he was first exposed to left-hand movement before practice (Time-1). This would manifest as left-hand muscular tension and a preoccupation with his nervousness and feelings of a headache. And as expected, his motivational competence and musical performance self-rating was low. In the baseline rest condition, GAV's individual alpha activity was not very indicative of his pain condition, but during and after musical execution moving IAPF, AAC, IABW and alpha power in IAPF + 2 Hz band decreased significantly. His MEOC (musical execution optimality coefficient (MEOC) was unexpectedly low for such a highly skilled musician (see Table 5.1).

Next, GAV's pain intensity and musical self-rating were measured in during the pre-intervention (Time-1), and then during the post-invention (Time-2) period. These results were then compared and the percentage change was calculated. The EEG and EMG recoding data of Time-1 in the baseline rest condition did not change over the first five days.

Nonbiofeedback interventions

Nozawa and Tacano (2009 revealed that self-warming of peripheral body parts such as the fingers or nose leads to a decrease in sympathetic nervous activity and an increase in blood flow within the peripheral vessels, while the arousal level declines. In accordance with Peniston and Kulkosky (1989) findings, I instructed GAV to attempt to increase the temperature of his fingers: "your arms and hands are very heavy and warm."

An important aspect for violinists is the necessity to keep "Postural control" during playing musical performance. Orchestra violinists maintain a center of gravity and keep their feet even while sitting on the chair. The body posture typically affects upper-alpha EEG activity, and will continue to increasing the more the upright posture is (Caldwell *et al.*, 2003). It has been found that maintaining tension in the lower part of the body combined with relaxing the upper-body posture will increases neuroplasticity (Ros *et al.*, 2010). Furthermore, it has been shown that differential modulation of EEG within alpha, beta, and gamma bands is a function of voluntary postural control (Slobounov *et al.*, 2008).

Next, I instructed GAV to focus on his breathing. I utilized breath patterns with short inhalation and long exhalation (Qin *et al.*, 2009): "concentrate on your breathing," "use abdominal muscles inhale short and exhale long," "inhale short through your nose," " make your exhale a little longer than your inhale," "concentrate on your exhale," "your exhale is long and easy," "try to imagine that you breath is like a wave," "your breathing should go smoothly and without effort."

The next strategy was to focus on "Frontal muscle relaxation." I directed GAV's attention to the area between his eyebrows and forehead (Perez-De-Abeniz and

Table 5.1 The EEG alpha activity, frontal muscle tension EMG and movement execution optimal indices before and after different strategies.

		Alpha peak frequency (Hz)	*Alpha peak amplitude (μV²)*	*Activation AAC (%)*	*Alpha band width (Hz)*	*Power in IAPF + 2 Hz*	*IEMG (μV²)*	*MEOC*
Baseline	rest (EC)	10.5	7.3	83	5.7	14.2	13	– 85.13
	movement(EC)	10.5	4.1	61	3.5	7.3	24	
Warming hands	rest (EC)	10.1	9.1	71	4.8	13.7	14	– 79.30
	movement(EC)	10.7	3.3	45	3.9	6.1	23	
Postural control	rest (EC)	10.8	6.9	78	5.2	15.1	11	– 47.06
	movement(EC)	11	4.2	62	3.7	10.5	15	
Breathing	rest (EC)	11	6.9	81	7.1	15.3	11	– 33.97
	movement(EC)	11.3	4.8	69	4.9	9.8	16	
Muscle relaxation	rest (EC)	10.6	7.2	87	7.2	17.2	8	– 13.10
	movement(EC)	10.8	5.1	75	5.1	10.3	9	
Post BFB 5 sessions	rest (EC)	12	9.2	97	11.2	21.3	5	18.91
	movement(EC)	12.2	5.9	96	11.7	25.2	4	

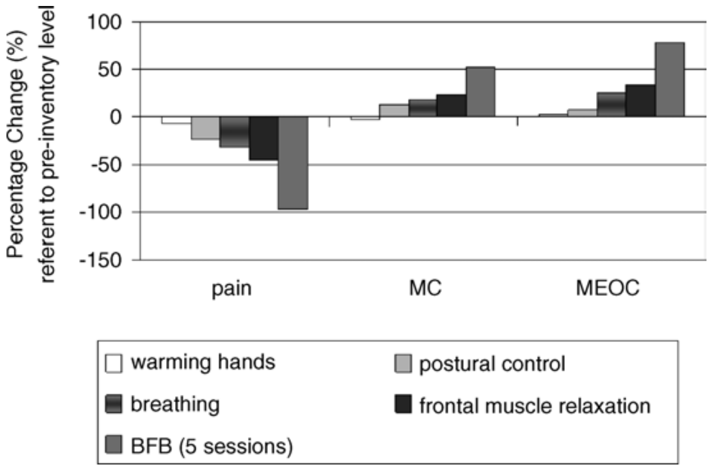


Figure 5.7 Self-regulation strategies impact on pain intensity, motivational competence (MC) and musical execution optimality coefficient (MEOC).

Holmes, 2000). I had GAV attempt to decrease the tension in his forehead and overall body. These instructions were provided every 1–2 minutes and could be accounted for by the relaxation of the facial muscles (Knost *et al.*, 1999; Prfwett and Adams, 1976). As was shown earlier, the decreases in the frontal EMG resulted in a mean alpha increase (Engel and Andersen, 2000).

As seen in Figure 5.7, ten minutes of practice combined with applying self-regulation strategies reduced hand-pain intensity, increased MC and MEOC, and improved musical performance. The least effective technique appeared to be the "warming hands" strategy because the "technique" and "rhythm" of musical performance decreased. I found it interesting that musical performance creativity did not change after all the applied strategies, with the exception of "warming hands," which is when it showed an increase.

As seen at Figure 5.8 and Table 5.1, all strategies increased the power in IAPF+2 Hz and decreased the frontal EMG tension in both rest and musical execution conditions except for the "Warming hands" strategy (Figure 5.9), which affected only alpha-1 power range. "Abdominal breathing," "Postural control" and "Frontal muscle relaxation" strategies shifted IAPF in on the right side (increasing frequency), enlarged the alpha band width and simultaneously, and increased the AAC (activation). So it could be concluded, that all self-regulation strategies were effective for GAV except for the "Warming hands" strategy, which increased the amplitude of the individual lower-alpha range.

Step 2

Up until this point, GAV had a total of eight BFB treatments lasting approximately 45 minutes each. A biofeedback intervention was designed by utilizing alpha EEG

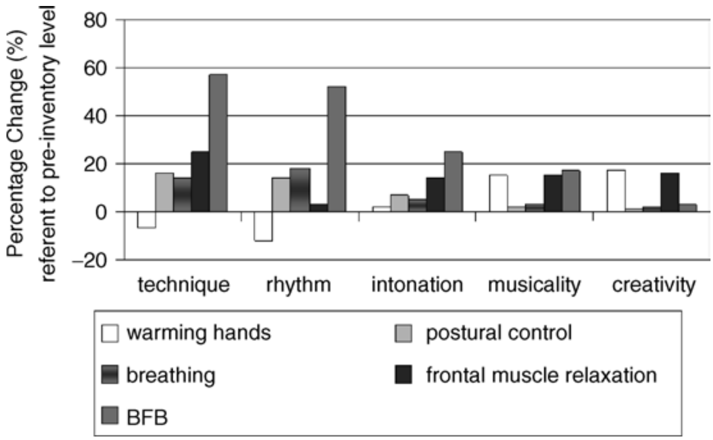


Figure 5.8 Self-regulation strategies impact on technique, rhythm, intonation, musicality, and creativity.

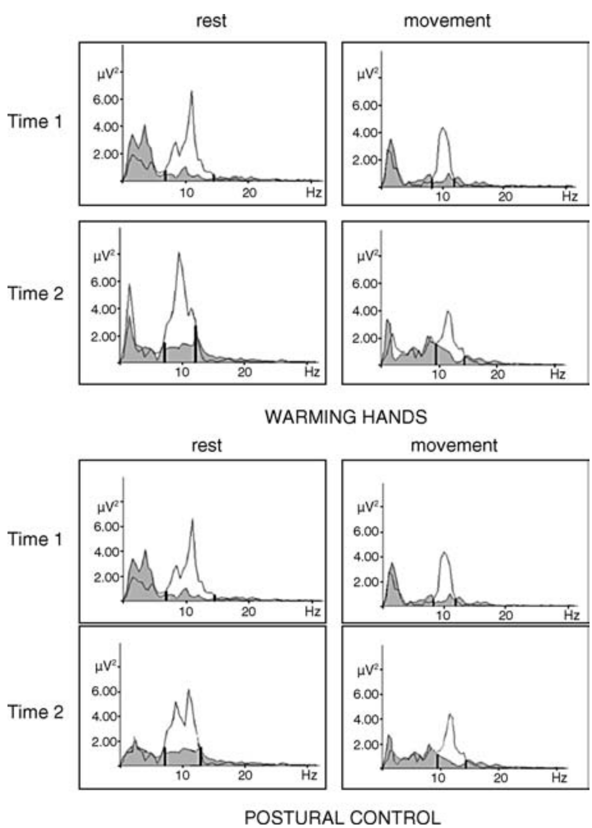


Figure 5.9 The EEG spectral data recorded in pre- (Time-1) and post-inventory (Time-2) periods in rest and musical execution movement conditions with eyes open (gray area) and closed (white area). The black bars point to the individual alpha band boundaries.

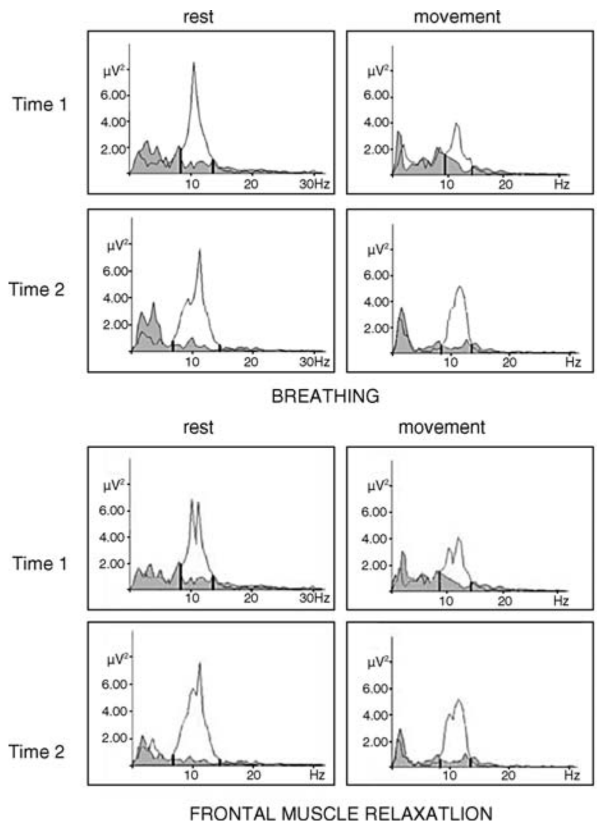


Figure 5.9 (*Continued*)

simultaneously with frontal-muscle EMG placement to assist GAV in learning how to relieve his hand pain, regulate his negative affective states, improve his self-motivational competence and, ultimately, his performance.

Practice combined with alpha EEG/EMG Biofeedback. The power of the IAPF+2 Hz band and IEMG averages were computed from a result of the analysis of EEG recorded during Time-1 (pre-intervention period) in eyes closed rest condition, which were used to determine the alpha power and IEMG thresholds. During the biofeedback sessions, simultaneous suprathreshold bursts of the alpha power and underthreshold bursts of IEMG were rewarded by an "applause" sound (see Figure 5.10). GAV received alpha-EEG/EMG biofeedback with a variable reinforcement threshold (no less than 30% screen time should be for suprathresholds for alpha and underthreshold for IEMG).

The specific protocol consisted of three 3-minute musical practice training periods with a 15-second break between each period. This allowed GAV time to

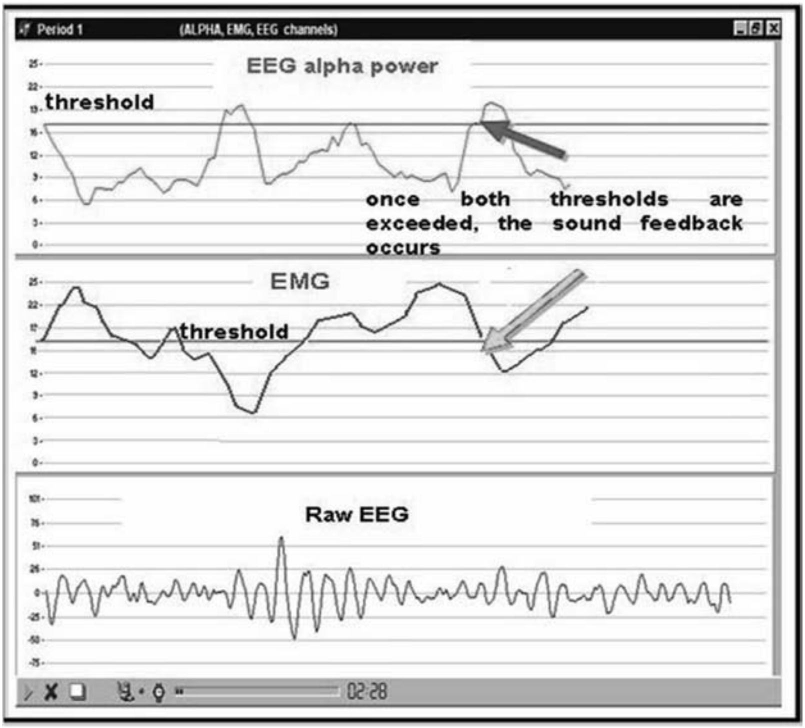


Figure 5.10 Suprathreshold bursts of the alpha power and underthreshold bursts of IEMG.

receive my instructions and to reflect on the strategies he used during the training. Created in the "MatLab" environment, the "successful training" intervals were defined as periods of a session when alpha-power increase was accompanied by simultaneous decrease in the IEMG power. The biofeedback session efficiency was calculated as the ratio of the successful training periods sum-duration compared to the whole biofeedback session length (see Figure 5.11). This ratio was titled as learning efficiency coefficient (Egner and Gruzelier, 2003).

Before and after every biofeedback session, I administered all the assessments which were applied before and after nonbiofeedback interventions. As seen at the Figure 5.12, the pain intensity decreased from session to session and simultaneously increased musical performance scores, motivational competence, musical execution optimality coefficient, and the biofeedback learning efficiency coefficient.

After the fifth session, I proposed that the next session should be the last. GAV relieved the pain in his hand, increased his MEOC, improved musical performance, and increased his biofeedback training efficiency. Here was a pint where I committed an error in retooling the frequency options. It's usual that biofeedback equipment and computer equipment are usually very reliable, but inevitably there will always be some type of glitches that needed to be dealt with. On a couple of occasions, I ran out

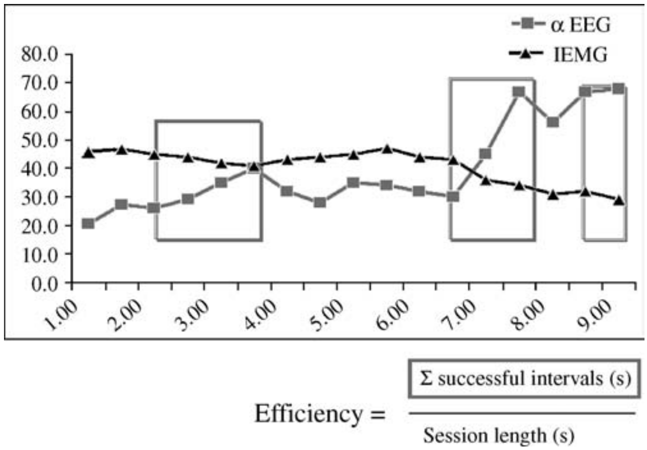


Figure 5.11 The μV power change in alpha EEG and frontal IEMG during 10 min EEG/EMG BFB session (abscissa – session duration time).

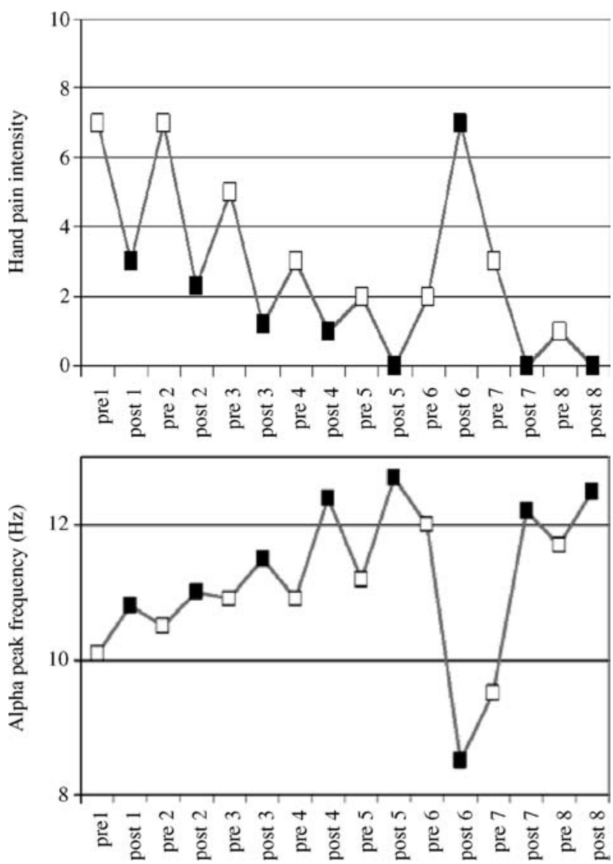


Figure 5.12 The hand pain intensity and alpha-peak frequency course through eight sessions in pre- (white squares) and post-session (black session) during musical execution.

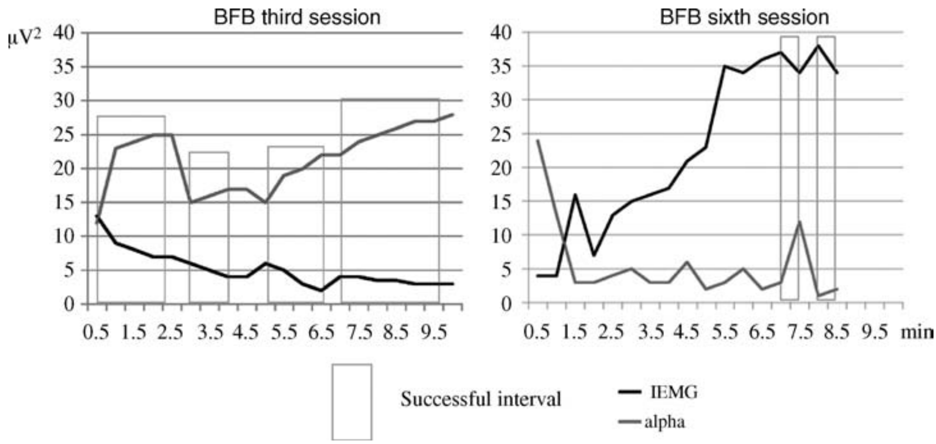


Figure 5.13 IEMG and alpha power during the third and sixth BFB sessions.

of battery power and had to replace the batteries and restart the program. When possible, I attempted to show up early to the lab, turn on the computer, and set up the biofeedback equipment with all the necessary sensors prepared to be attached. This allowed me time to reconfigure or work out any unexpected kinks that might slow down the process. The focus was to deal with and help GAV's affective-regulation issues and not have to worry about network connections, battery life, software issues, and biofeedback hardware issues. Boslab equipment is the type of software which requires the practitioner to manually set the individual parameters for each patient. It is easy to forget, for example, to change the alpha-band boundaries prior to the start of a session. For instance, I did not change the 8–10 Hz range of previous patient's settings for GAV's 12–14 Hz options. As a result, GAV tried to increase alpha power in a much lower range than what he should be training under and it actually gave GAV a headache. During the sixth biofeedback session, GAV was trained to increase his individual theta or low alpha, instead IAPF+2 Hz power. As shown in Figure 5.13, GAV's EEG demonstrated reduction in alpha-peak frequency, which was correlated with the increasing headache attack duration ($r = -0.45$, $p = 0.002$). Simultaneously, with the appearance of pain, an IAPF reduction and alpha power in upper-alpha range decreased the IEMG sharply increased (see Figure 5.11). I showed GAV the 6th session IEMG and alpha-course dynamic. I explained to him that his sudden pain is what is known as a tension headache, which comprises about one-third of all reported headaches. With this type of headache, pain does not come from inside the head, but is due to the steady contraction of muscles in the neck and scalp regions. I let GAV understand that his headache was a result of my error in properly setting the correct parameters in the equipment. Bjørk *et al.*'s (2009) study demonstrated a very similar conclusion, in that a tension headache may occur with a decreased alpha-peak frequency (Bjørk *et al.*, 2009).

Following the error, I gave GAV a break for 30 minutes, and then with GAV's agreement provided a seventh biofeedback session. I was sure to include all the appropriate settings and ranges for GAV. During this session, GAV demonstrated great skill and self-control. In fact, GAV also agreed to complete an eighth session. After the completion of the eighth session, GAV was able to relieve all his pain and he expressed to me that he achieved success in the last two sessions because of his training in the use of all the approaches, which would ultimately lead to an increase in his upper-alpha power.

Step 3

As a teacher with a lot of training experience, and GAV as an experienced student in receiving BFB, he understood very well that the most important part aspect of biofeedback is the mental practice. So I decided to explore with GAV the effectiveness of mental practice. Mental practice refers to the function of repeating a physical skill within the mind, without any physical movement of the body, and with the intention of learning or refinement. There is strong evidence that has shown that mental practice has a moderate but extremely reliable effect on performance (Mahmoudi and Erfanian, 2006). It was suggested that the mental rehearsal duplicates the actual motor pattern that is being rehearsed (Decety, 1996). Motor imagery is defined as a dynamic state during which representation of a given motor act is internally rehearsed in the working memory without any overt motor output. Through mental concentration, the mind is focused on a single goal for a period of time, without jumping from one object to another like in meditative practice. Aftanas and Golosheykin (2000) reported that meditative experiences, characterized by less complex dynamics of the EEG, involves "switching off" irrelevant networks for the maintenance of focused internalized attention and inhibition of inappropriate information. According to this view, it seems logical that mental practice should modify the neuronal activity in the primary sensorimotor areas and consequently change the performance of EEG-based biofeedback training. With this in mind, I asked GAV to appropriately charge himself up as if he was actually playing the violin. It was very exciting to see that one mental practice session had the same impact as the eighth biofeedback session: musical performance self-rating, motivational competence increased, individual alpha indices level enhanced (IAPF, IABW, AAC) and MEOC raised in the post-inventory state in comparison with the pre-mental practice condition.

Step 4

In Step 4, Transformation, I had GAV utilize all that he had learned in Steps 1–3. We had one more session scheduled for the lab involving self-practice through mental practice and relaxation skills with the objective of improving the controllability of the mind and rehearsing the actual motor pattern (Perez-De-Abeniz and

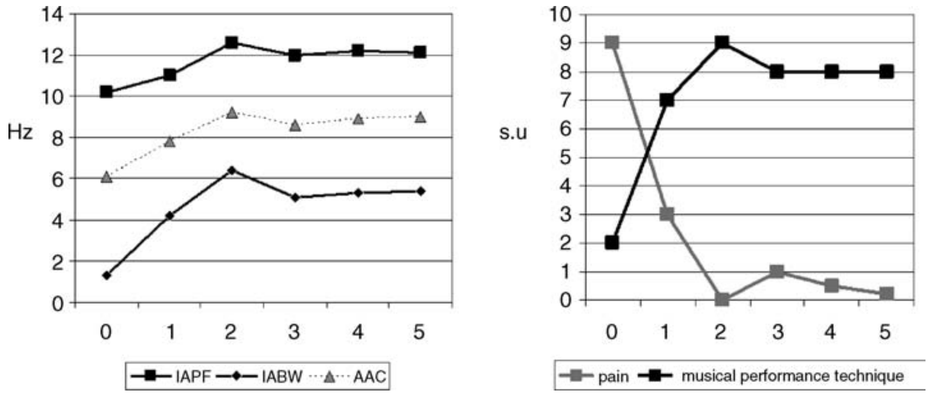


Figure 5.14 The individual alpha-peak frequency (IAPF), alpha-band width (IABW) and alpha-attenuation coefficient (AAC) at left plot, the pain intensity and musical performance technique through the 5-steps intervention.

Holmes, 2000). Therefore, I had GAV come to the lab and practice one more time using the procedures detailed in Step 3.

Step 5

During the next two weeks, GAV applied, in his actual practice, everything that he had learned from the training he had learned from Steps 1–4. This included "postural control," "frontal muscle relaxation," and "breathing" strategies. As seen in Figure 5.14, all the trained strategies during Step 2 helped to set the foundation improved performance functioning during the next 3–5 steps.

Outcomes and Discussion of Findings

Overall, GAV responded positively to the biofeedback training and started the new academic year with new all his new self-regulatory strategies in his "tool" box. I called him to ask how the first month of the academic year went, and he responded, "I'm surprised what a difference all the biofeedback training has made and helped me get my mind 'right' so I can be a better teacher!" GAV reported that he was able to teach and have them utilize all the learned techniques to his students, as well as himself during times of "need" (e.g. during times of high anxiety). Interestingly enough, GAV stated that the "warming hands" technique seemed to be helpful for some of his students too. GAV enjoyed working with the biofeedback so much that he recommended that his students come to the lab to experiment with different forms of biofeedback to strengthen their ability to regulate their affective states, as well as work on technical playing defects. GAV also mentioned that his relationship with his students had improved, and he was looks forward to learning more self-regulatory techniques so he can applying them with his students.

It is necessary to add that GAV's accomplishments cannot be solely attributed to the biofeedback intervention. I believe his accomplishments were primarily a result of his work and devotion as a teacher and highly skilled musician. However, the intervention served as a mediating variable that allowed GAV to move past his inability to overcome his hand pain and to regulate some of his negative emotions, improve his confidence and focus on the important technical aspects of training. From a theoretical standpoint, addressing his physiological and affective states nurtured aspects such as motivational competence and performance accomplishments (Bandura, 2000).

On a final, but important note: the practitioner must always remember that the individual frequency range must be adjusted as necessary (i.e. the individual frequencies options must be very carefully configured before every session, because biofeedback can work in both positive and negative directions).

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6

Case 4 – The Golfer Who Couldn't Pass the Anxiety Test!

D. Jane Arave

Background Information of Client

When this client inquired about mental training using biofeedback and neurofeedback, he was a 45-year-old male Professional Golf Association (PGA) Level 1 assistant at a country club in South Carolina. I will refer to him as "Al." After retiring from the Marine Corp, Al became a golf course manager and his desire to become a member of the PGA became his goal. He was a self-taught golfer with no formal training. By watching others, asking for tips, reading books, watching training videos and continuous practice, he became a golfer whose average score was in the mid-70s.

Without going into too much detail on becoming a PGA member, the basic rules are that an applicant must have the right job experience and complete the PGA Management Program. The PGA Management Program includes passing the Playing Ability Test (PAT) requirements as defined in *The PGA Constitution and Bylaws*. The PAT is a 36-hole competition played in one day. The total score must be within 15 shots of the course rating. The PAT is played from the middle tees and the flagsticks are placed on a flat area of the green. Even though this sounds like a relatively simple achievement for most skilled golfers, less than 20% pass the test.

Al's career as a PGA Professional depended on him passing this test. The PGA policy at the time Al started required that the PAT had to be passed before forward movement could be made to become a member. In 1999, he made his first attempt at the PAT and failed. The PGA allows you to take the test as many times as necessary until you pass the test as long as the score is within a certain range of passing. So, Al retook the test 22 times between 1999 and 2007. Al came within two strokes of passing during four of the attempts, but had twice become so frustrated that he walked off the course.

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On Being a "Mental Coach"

Even though I am a Licensed Professional Counselor, when I work with athletes, I take on the role of "mental coach" or "mental trainer." I make it very clear that I can in no way directly help with the mechanics of the sport. I also maintain the focus of the sessions on mental training and do not incorporate psychotherapy unless it is specifically requested for a minor concern. In order to maintain a distinction between the mental training and counseling, I normally refer any athlete who has obvious mental health issues unrelated to his sport.

Of great importance to the trainer/trainee relationship is the ability to bond and build trust. Being a "mental coach" is very different from a physical skills coach (Rotella, 1995, 1996). A mental coach teaches mental skills that provide the athlete with tools to aid in emotional self-regulation such as a reduction of negative thinking, the ability to not self-judge and not allow self- and/or other-expectations to have any influence on his/her mental state. A mental coach must also be able to project the mental state that is being taught onto the trainee. In other words, the mental coach must create a calm and relaxed atmosphere for learning to occur. The mental coach has to convince the trainee to trust and commit to the process even though a lot of what the athlete is being taught may not make any sense in the beginning. It is also vitally important for the mental coach to create a sense of excitement in the trainee toward the use of biofeedback equipment and the prospective outcome of the training.

Description of the Presenting Problem

Al presented as very friendly, open, talkative, self-assured and intelligent. Rapport was easily established with him. He was very eager and motivated to learn the mental game. He had already read many books on the topic, but was unable to self-apply the concepts. Al knew that he was skilled enough at the mechanics of golf to pass the Playing Ability Test, but he "continuously lost his focus and self-confidence" when he attempted to pass the PAT. He stated that he experienced a lot of anxiety because of several different factors: he was playing with mostly young college players and didn't feel like he belonged; he was playing with people he didn't know; he was playing on a course that he didn't usually play on; and he was playing 36 holes for 8–10 hours straight with only a short lunch break. He said that he worried about everything each time he tried to pass the PAT.

Apart from the Playing Ability Test, Al felt good about his golf game and his mechanical skills. On average, he played golf three times per week and enjoyed the game. He never felt stress even when he was competing against friends or the PGA Professionals with whom he worked. It was not uncommon for him to win these games. He also felt confident as a golf instructor. Al's claims were substantiated when we did the first on-course training and he introduced me to his PGA professional supervisors and two of his golf students. Everyone was very positive about Al's abilities.

Biofeedback and Neurofeedback Protocol – Assessment, Diagnosis, and Training

The "Mental Game of Golf Protocol" was created and developed by the author, Jane Arave. It is a 12-session protocol that has been used successfully for all golfers who have been motivated enough to work through and finish the program. Many golfers have improved their games in only 12 sessions, but Al had to have more than the 12. Most of the sessions are $1^1/_2$ –2 hours in length.

There is an old Russian proverb that states, "Repetition is the mother of all learning." I have found that the key to my success in working with athletes is repetition, repetition, repetition. I never assume that the golfer "gets it" the first time I say it. In fact, I know the golfer won't get it the first time or the second time I say something or instruct him on how to do learn a process that will help him self-regulate his emotional and physical state. That is why everything is repeated multiple times in this protocol until automaticity and mental economy occur.

The basic steps of the protocol (which are subject to change based on the individual needs of the athlete) are:

1. Consultation, beginning of intake interview, explanation and demonstration of biofeedback and neurofeedback hardware and software, verbal commitment to the process required before moving forward.
2. Biofeedback assessments, introduction to diaphragmatic breathing, introduction to emWave PC and Heart Rate Variability (HRV), homework assigned.
3. Neurofeedback assessment, introduction to mind/body awareness training, introduction to mental pre-shot routine, homework check. *Note: If clinician is not trained in neurofeedback, this step can be omitted or the client can be referred for a NF assessment.
4. Beginning of surface electromyography (sEMG) muscle tension/relaxation awareness training, breathing and emWave, practicing mental pre-shot routine while putting, homework check.
5. sEMG training, breathing and emWave, practicing mental pre-shot routine while putting, homework check.
6. sEMG training on the driving range, respiration monitoring, and mental pre-shot routine practice.
7. Breathing and emWave, sEMG training, mental pre-shot routine practice and EEG training.
8. Breathing and emWave, sEMG training, mental pre-shot routine practice and EEG training as needed. This would include relaxed focus training, calming the brain, increasing ability to handle stress and reducing negative thinking.
9. Same as session 8 except trainee begins to say aloud the steps of the mental pre-shot routine.
10. Same as session 9.
11. Same as session 10.
12. Practicing skills on the golf course with trainer observing.

My first meeting with Al was an hour consultation. The purpose of this consultation was for me to explain to Al what to expect and what would be expected of him. It is very important for an athlete to be self-motivated and have the drive to move forward in his competency. I let him know that there would be homework and that overcoming the mental obstacles that were hindering his game during the PAT would be a process – one that must be worked at, committed to, and trusted. During this meeting, I also introduced Al to the biofeedback equipment and demonstrated previously recorded training and assessment sessions including reports. By this point, Al was ready, willing, able and excited about starting the training. Most importantly, Al had a positive attitude and a strong belief that this training process was going to work for him. This was the beginning of increasing his self-confidence. Even though I did not have Alan sign a written contract, I did request a verbal agreement of commitment.

Our next meeting was actually the first session. I obtained more information about Al's golf game through an interview and biofeedback assessments. I personally did not use a formal interview, but simply allowed Al to tell his story and direct the discussion. This is entirely a personal preference and I have found that this is also a means of quickly developing trust, concern, and care in the relationship. It became obvious in the interview that Al was experiencing performance anxiety and low self-confidence during his attempts at the PAT.

In my experience, both peripheral biofeedback and neurofeedback assessments are very important for analyzing the condition of the client/athlete. I administered a biofeedback stress assessment to discover Al's baseline physiological measures, how he responded to cognitive stressors, which body systems were involved and whether or not he quickly recovered from the stress response (Andreassi, 2007).

The physiological stress test included: (a) a pre-baseline period; (b) the Stroop Colored Word Test; (c) recovery; (d) Serial 7s; (e) recovery; (f) a stressful or embarrassing event recall related to golf; and (g) recovery. The stress test measures: skin conductance which measures electrical activity/sweat activity on the palmar side of the nondominant hand in microSiemens (μS) or microMhos (μMhos) using silver/silver chloride electrodes; temperature using a thermistor on the nondominant little finger in Fahrenheit, heart rate in beats per minute derived from blood volume pulse (BVP) with the sensor placed on the thumb or pointer finger of the nondominant hand; surface electromyography (sEMG) using pre-gelled electrodes. Surface EMG measures bioelectrical muscle contraction in microvolts (μV). I use a wide sensor placement on the frontalis muscles of the forehead which gives me information about muscle tension in the face and possibly down to the neck; and respiration in breaths per minute with the respiration belt sensor placed two-finger widths above the navel.

We expect to see physiological responses to the presented stressors indicating an autonomic nervous system reaction (specifically the sympathetic nervous system) with a return to baseline during the recovery period. Due to individual differences in response, we may or may not see what we expect to see (Blumenstein *et al.*, 2002).

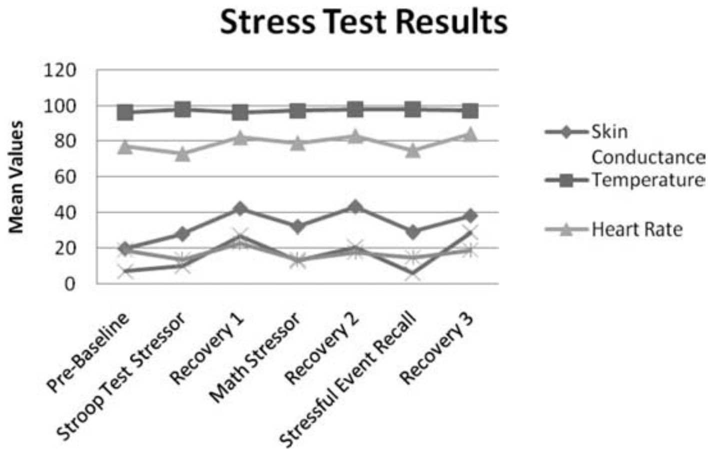

Figure 6.1 Mean values across each aspect of the Stress Test.

Figure 6.1 is a graph of Al's mean values during the stress test. The results indicated no significant sympathetic response in Alan's cardiovascular system as shown in skin temperature or heart rate. Al's respiration rate, sEMG, and skin conductance data gave me valuable information about him. First of all, these modalities started high and remained high throughout the assessment. He was told to relax and sit quietly during the pre-baseline condition and the recovery periods, but Al was breathing at a rate of 19 breaths per minute during the pre-baseline, rose to 23 breaths per minute during the Stroop Test recovery, and was still at 19 breaths per minute in the final recovery. His breathing rate dropped during the stressor conditions, but this could have been due to breath-holding during verbal responses. At no time did his respiration rate drop below 14 breaths per minute. Skin conductance measures changes in the amount of moisture in the hands and is a good indicator of autonomic response to stress and the degree of arousal. Al's pre-baseline measure of 20 μMhos rose throughout the stress test and ranged between 28 and 43 μMhos ending with 38 μMhos in the final recovery period. Al's sEMG readings began at 7 μVs and rose as high as 29 μVs during the last recovery. In all modalities, Al's highest values were during the recovery times when it is expected that a person will relax and return to or move toward baseline. Since no electroencephalogram (EEG) data was being monitored during this assessment, I could only suspect that during the recovery conditions, Al was worrying and ruminating over his performance which caused a greater sympathetic nervous system stress response.

I also administered the Upper Trapezius Evaluation surface electromyography (sEMG) assessment (see Figure 6.2) using a wide sensor placement positioned symmetrically on the right and left upper trapezius muscles. By using a wide sensor placement, I was able to get combined information on both of the upper trapezius and surrounding muscle groups (upper back quadrants).

I did this assessment based on my own hypothesis that asymmetry in the upper body would have an effect on the trajectory of the ball during both putting and

Figure 6.2 Sensor placement for sEMG assessment.

driving. I believe that asymmetry indicated by the Upper Trapezius Assessment can also indicate injury and cause hooks and slices. It is also well known that increased muscle tension decreases fluidity of movement.

A lot of research has been done with upper trapezius muscle asymmetry and pain patients. One of these researchers is Susan Middaugh, PhD who told me, "The upper traps are the crossroads for motor control in the head/neck/arms (upper body)."

With pain patients, marked asymmetry is only significant when there is a 50% difference during movement and an amplitude > 4 uVs during a resting condition (Coh *et al.*, 2004). My interest with golfers has been in the asymmetry at rest and recovery after movement while in the standing position. Al had tension in both upper trapezius muscle areas which was significantly greater after each movement. In other words, he did not recover quickly after a movement and was totally unaware of this residual tension (see Figures 6.3 and 6.4).

Both the Stress Assessment and the Upper Trapezius Evaluation were protocols developed by Phillip A. Hughes, PhD for the NeXus-10™ using BioTrace + software. The NeXus-10™ is a 10-channel physiological monitoring and feedback platform that uses BlueTooth wireless communication developed by Mind-Media BV in the Netherlands. The sensors used in the stress protocol were: NX-BVP1C BVP sensor; NX-EXG2B dual-channel sensor for EMG; NX-GSR1D skin conductance sensor; NX-RSP1A respiration sensor; and NX-TMP1A temperature sensor. The Upper Trapezius Evaluation used the NX-EXG2B dual-channel sensor.

I was able to quickly calculate the statistics with the software and discuss the results with Al in this session. He was quite surprised by the results as he did not realize that he was breathing so rapidly or that he was holding so much tension in his muscles. He was aware that his hands felt "clammy" very often. So, Al had definite

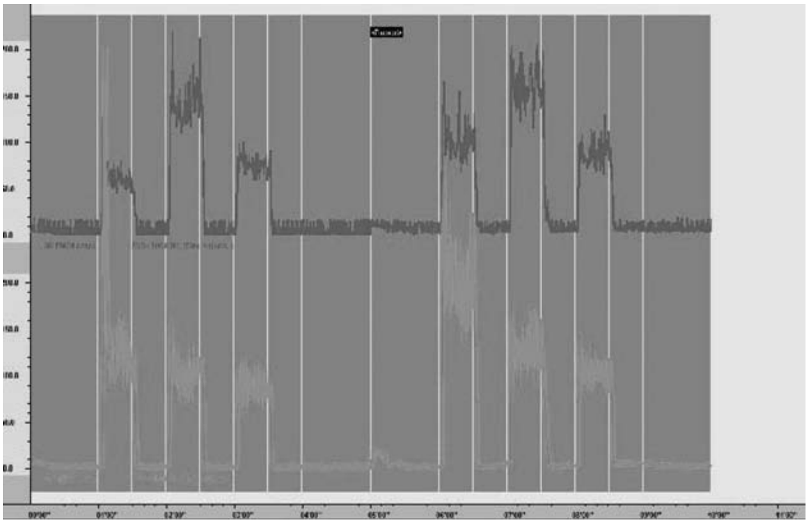

Figure 6.3 sEMG readings indicating asymmetry.

BEHAVIOR or CONDITION	EMG 1 (LT) Ampl Mean	EMG 2 (RT) Ampl Mean	EMG1/EMG2 Ratio	% Difference
SITTING				
Baseline	3.27	2.38	1.37	
Shrug	44.33	83.57	0.53	46.95%
Recovery	5.67	7.75	0.73	
Abduction	103.35	73.91	1.40	28.49%
Recovery	10.83	8.68	1.25	
Flexion	54.60	63.65	0.86	14.22%
Recovery	6.65	6.16	1.08	
Post-Baseline	2.92	1.65	1.77	
STANDING				
Baseline	4.88	4.40	1.11	
Shrug	73.00	149.19	0.49	51.07%
Recovery	8.91	12.01	0.74	
Abduction	114.72	87.78	1.31	23.48%
Recovery	15.35	11.14	1.38	
Flexion	61.51	72.86	0.84	15.58%
Recovery	9.94	10.36	0.96	
Post-Baseline	5.01	2.68	1.87	

Figure 6.4 sEMG descriptive statistics for sitting and standing conditions.

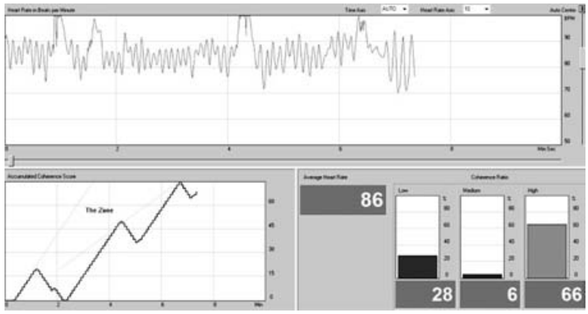

Figure 6.5 HeartMath emWave display.

signs of the stress response – increased sweating, respiration and muscle tension. The questions I had to ask myself were: Was this Al's normal heart rate? Did Al always breathe this rapidly? Or, was this another "test" that Al was responding to in a "fight or flight" manner – from start to finish?

At the end of the first session, I introduced Al to diaphragmatic breathing. I had him put one hand on his chest and one hand on his upper abdomen and told him to breathe normally. It appeared that Al was taking shallow chest breaths since only his hand on his chest was moving in an in-and-out motion. He was then instructed on how to breathe diaphragmatically. I also connected Al to HeartMath's emWave PC™. Figure 6.5 shows Al's first attempt on the emWave using the low challenge level.

Al was given homework assignments beginning with Session 1. Homework is a very important element in the training process because, for example, if an athlete only practiced diaphragmatic breathing during the sessions it would take forever for him to learn to slow his breathing down and use his diaphragm. He was instructed to pay close attention to his breathing and practice breathing with his diaphragm. He was given "memory dots" (colored sticky dots that can be purchased at any office supply store) to place in locations that he frequented – car, favorite chair, computer, golf bag, etc. The purpose of the memory dots was to remind him to do his homework. He was also given a homework journal to write down how often and for how long he practiced his breathing.

In the second session, I conducted a mini-EEG assessment that was developed by Peter van Deusen and François DuPont, PhD called The Learning Curve (TLC). The TLC is a 2-channel assessment that measures brainwave frequencies at five pairs of sequential sites on the scalp. According to the International 10–20 system, the recording sites were C3/C4, P3/P4, T3/T4, F3/F4 and Fz/Oz. At each pair of recording sites, there were three conditions: (a) Eyes Open; (b) Eyes Closed; and (c) Cognitive Task.

The most prominent feature in Al's EEG was the amount of high beta (23–38 Hz) that his brain was producing as seen in Figure 6.6 (Collura, 2003; Collura and Fischer, 1997). This indicates how his brain activates under different conditions (Bailey *et al.*, 2008). Moving from left to right, the maps show percent of high beta with eyes closed, eyes open, and task performance (Capotosto *et al.*, 2009). The

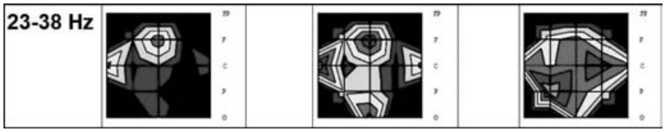

Figure 6.6 EEG display.

bright colors indicate a higher percentage of this frequency range. From a dorsal view, the top of each picture represents the frontal region and the bottom of the picture is the back of the head. High Beta amplitudes can indicate anxiety, obsessive thinking, worrying and/or a tendency to ruminate.

The EEG assessment known as The Learning Curve (TLC) was developed for Thought Technology's ProComp Infiniti, an eight-channel multimodality encoder, by the Biofeedback Foundation of Europe (BFE). Two channels of EEG were recorded using two EEG-Z (pre-amplified EEG sensors with built-in impedance checking) connected to two TT-EEG gold cup cables and linked ear references and grounds using two TT-EEG gold ear clips (Davidson, 2004).

According to my interpretation of the results, these biofeedback and neurofeedback assessments correlated with Al's subjective reports of anxiety and worry during the Playing Ability Test (Baumeister *et al.*, 2008). The goal of mental training for a golfer is to teach him to stay in the present moment, to stay calm or quickly return to a neutral emotional state by relaxing and clearing his mind, and to enjoy playing the game. Al was unable to self-regulate his emotional state and needed tools to enable him to manage these repetitive physiological reaction patterns (Arns *et al.*, 2008; Babiloni *et al.*, 2008). Even though the biofeedback and neurofeedback assessments were different scenarios from being on the golf course competing for a passing score on the PAT, Al admitted that he felt a great deal of concern as to whether or not he was doing well on the assessments.

At the beginning of each session, we reviewed Al's homework journal. He had been practicing his diaphragmatic breathing regularly and had already brought his breathing rate down to six breaths per minute. Al was instructed to use the breathing technique not only to calm himself, but also as something to focus on other than his golf game.

Al was also given a new tool in this session – "The Awareness Exercise." He was taught to be aware of various things coming in through his five senses. For example, he was told to "Be aware of the feel of the pressure of the chair against his back," to "Be aware of the feel of the shoe against your left small toe," etc. This exercise lasted for approximately ten minutes. This exercise was also added to his homework journal to be practiced on a daily basis. Al was told he could do this anywhere and anytime. The "memory dots" were now not only to remind him to practice his breathing, but also to do his "awareness" training. Al was reminded that this was another tool he could use on the golf course to take his mind off of the game and keep himself in the here and now.

Al was then introduced to the mental pre-shot routine. A mental pre-shot routine is done prior to each shot with no exceptions. It is a step-by-step "ritual" that

Figure 6.7 HeartMath emWave device.

involves breathing, mind-body awareness, choosing a target and visualizing (Chabris and Hearst, 2003).

At the beginning of each in-office session, the homework journal was reviewed. Al continuously practiced his breathing and awareness exercises on a regular basis. Al was also connected to Heartmath's emWave PC for about ten minutes at the start of each session. The emWave PC teaches Heart Rate Variability (HRV). Since golf is played in a standing position, he practiced on the emWave while standing. Al also chose to purchase the personal emWave (Figure 6.7), which is small enough to fit in a shirt pocket and is available with an ear clip so that he could practice HRV at home and on the golf course.

In the third session, Al began using sEMG training during putting practice. Two channels of sEMG on each of Al's Upper Trapezius muscle quadrants were monitored using a wide sensor placement with the wireless Nexus-10™. By facing the monitor, Al was able to watch the training screen and reduce both sides below 5 μV. When Al lowered his sEMG, a low-tone audio feedback would turn off. A golf cup was placed at various distances to Al's left from 5 feet to 20 feet away. When Al's upper trap areas were relaxed, he would look at the cup (his target), look down at his ball, and swing. When both quadrants were relaxed and almost symmetrical, the ball would either go into the cup or stop within inches of the cup. In order for Al to be able to recognize when his muscles were relaxed, this sEMG training was done repetitively until he no longer needed the feedback.

The pre-shot routine was also practiced while putting in the office. For this training, sEMG sensors were placed on the upper trapezius muscle and the flexor muscle on Al's forearm of his lead arm. The lead arm in golf is the arm closest to the hole. By monitoring the forearm, I was able to teach what I referred to as "soft hands" to make Al aware of when he was gripping the club too tightly. Once again, Al was instructed to bring the sEMG amplitude down below 5 μVs. Respiration rate was also monitored. Figure 6.8 shows one of Al's early training sessions.

For the mental pre-shot routine, Al would stand behind the ball facing the cup, reduce his breathing rate to six breaths per minute, check his body for muscle tension, choose a target, and visualize the ball going to the target using the same state

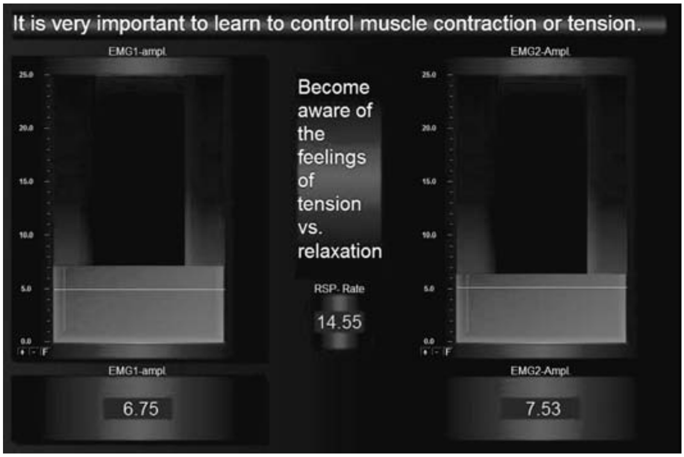

Figure 6.8 Bilateral sEMG training screen.

of mind as he had developed for the awareness exercise. When ready, he would step up to the ball, take his putting position, look at his target, look down at his ball and swing. To minimize any excessive muscle movement, he was taught the "quiet eye." For the "quiet eye," the golfer keeps his eyes focused on the ball's position even after the ball has been hit.

It was also during this session that we "reframed" the Playing Ability Test and started referring to it as the "Playing Game." I decided to do this in case the word "test" was having a negative impact on Al's emotional state. He was also instructed to start acting "as if" he had already passed the "Playing Game."

Sessions 4 and 5 were repeats of session 3 – homework review, emWave, sEMG and respiration training, and practicing the mental pre-shot routine. In a soft soothing voice, I would repeat the steps of the pre-shot routine over and over again each time it was practiced. Remember – "REPETITION, REPETITION, REPETITION!"

The success that Al was having with biofeedback was beginning to increase his self-confidence. He was now able to breathe easily and comfortably at a rate of six breaths per minute, he knew exactly when his muscles were relaxed without looking at the computer monitor, and he was now using his new skills when he played golf with friends. He was becoming more and more convinced that he could do this.

In session 6, we took the laptop computer and the Nexus-10™ out onto the driving range. Once again we monitored two sEMG sites (both upper trap areas using a wide sensor placement) and respiration. Before each drive, the steps of the pre-shot routine were stated quietly in a soft soothing voice by me and implemented by Al.

In session 7, neurofeedback was added to the program. I wanted to confirm that Al was not continuing to have residual focus and negative thinking issues. I trained Al on both the ProComp Infiniti and the Nexus-10. Figure 6.9 is an example of a training screen I used to inhibit Theta and reward the Sensory Motor Rhythm (SMR) at Cz over the sensory-motor cortex. This training was used to help Al

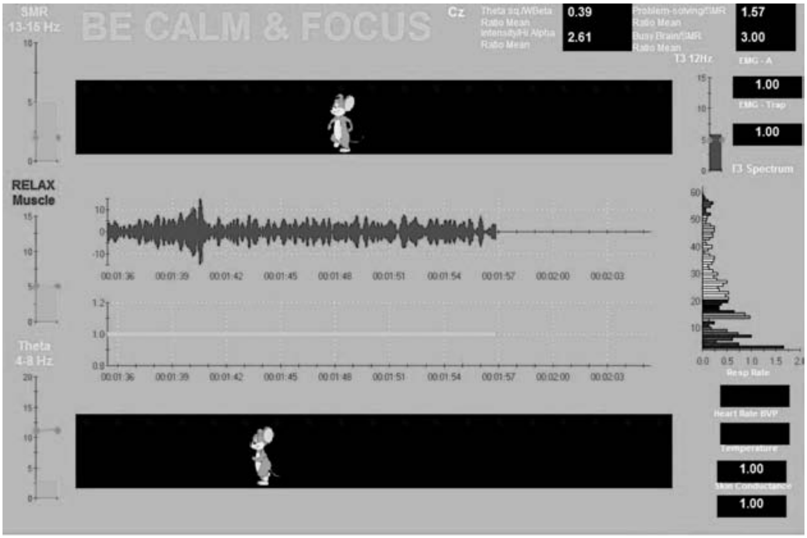

Figure 6.9 Screenshot from Wilson's BFE Optimum Performance and Health Suite.

improve his ability to produce a relaxed state of focused. This screen was taken from Vietta (Sue) Wilson's BFE Optimum Performance and Health Suite. While training, I noticed data that indicated Al was still having difficulty with his high Beta based on his Intensity/High Alpha and his Busy Brain/SMR ratios. If above normal ranges, these ratios can indicate worry and rumination.

I also did training on Al's Theta/Beta ratio that was high in his EEG assessment and did several sessions to decrease his high Beta amplitudes (Wilson *et al.*, 2006). During each session, we continued to review his homework, practice diaphragmatic breathing, do the emWave HRV training, monitor muscle tension/relaxation while putting and continued to work on his pre-shot routine until all of these processes became automatic.

The final sessions were repeats of session 7. Each individual athlete is different and while many have finished "The Mental Game of Golf" program in as little as 12 sessions, Al did 16 sessions at his request to make sure he was ready for the next Playing Ability Test. It was coming soon and he had already registered for it.

Outcome and Discussion

In order for any athlete – amateur or professional – to perform at his/her optimal level, there are several constants that must occur regularly. The athlete must be self-motivated, have a strong desire to overcome mental obstacles, and be willing to work hard physically and mentally. For talented athletes, the physical capabilities must be in place. Whether the talent has developed from natural abilities or a strong desire to excel, hours and hours of practice are necessary. Skill and competency are developed through practice. Mental skills are just as important as physical skills. Slower and deeper diaphragmatic breathing, mind/body awareness, relaxed focus, ridding the mind of negative thoughts, keeping emotions in-check – not allowing yourself to get too upset or too elated, are all examples of mental skills that must be practiced and developed to a state of competency (Vernon, 2005).

These are also tools that the athlete can use to stay in the here and now (the present moment) in order to play his best on this particular play (Milton *et al.*, 2007). The only play that matters in the entire game is the one that is being played NOW – right this very minute. I always ask athletes "Can your body travel through space and time to the future or the past?" They always give me a funny look and say something like, "Well, no!" Then I ask them, "Can your thinking mind travel through space and time to the future or the past?" Then I usually get a chuckle and a "Of course it can!" I then get very serious and tell them, "Well, if you want to play your very best, then keep your mind with your body – this play, 'right here, right now' is the only play and the only time that matters until the next play. Then you move forward to the next 'right here, right now' play."

So, what happened with Al? Al was given tools for overcoming mental obstacles and he was taught the skills needed to implement the tools. Basically, Al was taught to balance his autonomic nervous system, to keep his emotional state in neutral or return quickly to a neutral emotional state, to not worry or complain about things he had no control over, and to accept whatever happens with a calm mind state (Smith *et al.*, 2000). Al was also taught that unless he became a robot (which was probably not going to happen), to accept that waves of disappointment, negative thoughts, anger, frustration, elation, or even a "look how GREAT I AM" attitude are bound to come in at times. But, Al learned that the trick is to go ahead and give himself a quick pat on the back or a quick "Ugh!" (or some other often used slang word), but then use the tools, use the new skills and return to neutral and the here and now as soon as possible. Al created his own mantra that he used while playing a game, "Be aware, but don't care."

Where do biofeedback and neurofeedback fit into all of this? Can't an athlete learn all of these same skills without the use of biofeedback and neurofeedback instruments? I have to say that yes, there are a few athletes and non-athletes who are born with an innate mind/body awareness, but for most of us, we never even think about having a brain or if we're doing things right or even if we could learn to think, act, and respond in a different way (see Edmonds *et al.*, 2006; Edmonds *et al.*, 2008; Johnson *et al.*, 2007). We just go through life acting and reacting in our own natural or learned way. Remember Al? Al had read every mental golf book that he could find. So, he knew what he was supposed to do, but was unable to "get out of his own way," as Dr Bob Rotella quite often says (Rotella, 2001). The biofeedback and neurofeedback instruments helped him to better understand this concept (Egner and Gruzelier, 2002). He could see visually on the computer screen when his heart rhythm was smooth indicating a balanced autonomic nervous system. He had made the mind/body connection that he needed to know when his body was tense or relaxed by seeing his muscle contraction in microvolts on the computer screen (Eusebi, 2009). He had learned to breathe slower and deeper in a way that evoked the relaxation response as he had followed the breathing pacer on the computer. He also now knew the feeling of being in a relaxed focused state of concentration as he had trained for this using the neurofeedback training screens (Griffiths *et al.*, 2005; Hammond, 2007).

Was Al now ready to pass the Playing Ability Test? In April 2007, Al went to the Coastal Carolina University golf course in Myrtle Beach, South Carolina to participate in the PAT. He was teamed up with two young college men. He had never played on this course before and he didn't know his teammates. Al shot one over par on the first two holes. Was he going to blow it again? He was thinking about having to shoot 156 for the 36 holes. He was listening to his teammates complaining about the course. Then, Al told me he heard my soft soothing voice say, "Breathe Al. Don't think about the score; just think about your breathing." He then realized he was getting ahead of himself instead of staying in the present moment. Al said that he began to focus on his breathing and he stopped thinking about his score and anything his teammates said to him or to each other. He said that as he started to practice his awareness and he began to believe in himself (see Gallwey, 2009). He remembered a sense of calm coming over him and he felt as though he was in his own bubble. He then made sure he did the mental pre-shot routine for every shot – even for a 1 or 2 foot putt. Al said that he became aware of the wind blowing the leaves of a tree instead of his opponent hitting the ball into the water. He knew that if he focused on the water, that his ball would end up in the water too. Even though he made a few more errors that day, he was able to "stay out of his own way" and return to his calm state.

Al called me during his short lunch break after the first 18 holes and in a very calm voice said, "I passed the first half." I simply said to him, "Call me back when you're done." At 5:00 pm, Al called me again. This time his voice sounded excited as he exclaimed, "I PASSED!" Now, it was time to feel the elation. Now, it was time to celebrate. Al had scored 155 out of 156. After eight years and 22 attempts, he had finally passed the Playing Ability Test. His two teammates failed the test that day.

The goal of this intervention was to help Al pass the PGA Playing Ability Test. Al had the mechanical ability all along to pass the PAT, but he lacked the ability to self-regulate his emotions and mental state. After practicing and practicing and practicing along with repetition, repetition, repetition, Al's brain reprogrammed itself to respond in a new way. Through repetition, Al had created a different brain map with new neural pathways that led to new ways of thinking and behaving. The old pathways were still there and the same old pattern almost won out, but he was able to bring himself back to his new way of being (Ros *et al.*, 2009).

Al moved to Pennsylvania shortly after passing the PAT. I spoke with him recently and he is still playing golf, but has also added equestrian activities to his list of interest. He said that he is continuing to use the mental skills he learned for golf with his riding and has been quite successful. He told me that he uses his breathing techniques, his awareness training and his muscle relaxation while he is riding and when he is preparing to ride (Nilsson and Marriott, 2005). He said that he also uses the soft soothing voice to calm the most nervous and panicked horses with great success (Parent, 2002).

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7

Case 5 – Biofeedback for Relaxation

Ronald Rosenthal

Introduction

Biofeedback training focuses on the acquisition or enhancement of self-regulatory skills. By self-regulation, we mean acquiring control over specific physiological systems. The therapist selects physiological systems that are relevant to the needs of the client. If a client has problems with incontinence, we can use sensors to monitor the activity of the pelvic floor muscles and train the client to have better control over these muscles. If the problem is migraine headaches, we can train the client to warm their hands and decrease muscle tension in the head, neck, and shoulders.

The most common applications of biofeedback training are for the improvement of relaxation skills. It is well known that high levels of stress can have a marked impact on mental and physical well being. When coping skills are not adequate to handle stressors, arousal increases and a number of physiological systems reflect this change. Biofeedback therapists have monitored and trained sweating (skin conductance), blood flow (temperature or photoplethysmography), muscle tension (EMG), respiration and heart rate in protocols to enhance relaxation skills and lower arousal. In recent years, there has been a growing emphasis on heart rate variability training which focuses on increasing specific rhythmic changes in heart rate. Heart rate variability is linked to slower respiration rates, but some theorists emphasize positive emotions as an important factor in the development of HRV.

In practice, many clinicians monitor multiple modalities simultaneously and training can switch between the different systems. It is important to foster a sense of mastery and control for the client and the initials protocols should be arranged to

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maximize success in the training. If a client is showing a consistent cooling trend with fingertip temperature in an initial session, it would be ill advised to start with hand warming biofeedback. It can be helpful to examine the record obtained during a baseline without feedback and then select a modality that is spontaneously showing a desired change.

During biofeedback training sessions, clients receive information about their physiology that is not usually available outside of the sessions. It is critical for the long term success of biofeedback training that clients learn to generalize their learned control to their natural environment. As training progresses, the clinician should emphasize a subjective focus on an internal awareness of changes that occur as the client learns to control the displays. Questions like, "What did you notice while you were doing that?" or "How did that feel?" can be helpful in getting the clients to become less dependent upon the feedback. It can also be useful to have the clients attempt to relax without feedback for a few minutes and then review the changes that occurred during the self-directed relaxation.

In this chapter, I will discuss biofeedback training I conducted with a middle-aged man with some typical, stress related complaints. I will attempt to depict the processes I went through as I conducted the training.

Background Information

My work with this client started when I was contacted by a middle-aged man who asked if I provided biofeedback and neurofeedback services. I told him that I had been providing biofeedback training for many years and I asked him why he had contacted me. He mentioned that his sister had received neurofeedback training and she had found it to be very helpful. She also told her brother that she thought that he could benefit from neurofeedback and told him to try to find a provider. The gentleman told me that his parents were also encouraging him to try biofeedback and they had agreed to pay for the training. I will call the client Bernard and we arranged for an initial consultation.

Bernard arrived on time for the consultation and he was friendly and responsive. He was a large man but he was also very heavy and weighed more than 250 pounds. Bernard noted that he had gained a lot of weight in the past few years and that he was in much better physical condition when he was younger. He told me that in high school he had been on the track team and I had a hard time picturing this obese man running up a flight of stairs, let alone running long distances.

Bernard reported a number of stress-related issues. He had a low frustration tolerance and would "lose it" when things went badly. He had difficulty staying on task and would get distracted and would find himself missing deadlines. He did not report any significant anxiety and stated that his mood was not particularly depressed. Bernard noted that his lifestyle was not particularly healthy and that he was fairly sedentary. When things went badly at work he would often eat excessively as a coping mechanism. He used the words "irritable" and "cranky" to describe himself.

Assessment and Diagnosis

After conducting the intake, I thought that we might be dealing with an underlying problem of attention deficit disorder. He already had an interest in neurofeedback based upon his sister's experience and I suggested that we proceed with an EEG evaluation to determine if he had a particular brainwave pattern that could be contributing to his problems in completing tasks. I conducted a mini QEEG to determine the theta beta ratio at the vertex. This assessment is based upon the published work of Monastra and colleagues and provides normative data for ratios of slow wave amplitudes (theta) to fast wave amplitudes (beta) for four age groups ranging from six years old to adults.

I used a standardized protocol to obtain a theta beta ratio at CZ. I localized the vertex (CZ) by measuring from the nasion to the inion and from the left to the right pre-auricular notches and using the midpoint of both measurements. I applied a recording electrode to the vertex with a reference electrode on the right earlobe and a ground electrode on the left earlobe. I verified that the set-up was clean and obtained at least one minute of EEG activity with eyes open, eyes closed, while reading, and while listening to me read him an article from a magazine.

Bernard did not show any elevation of theta beta ratios typically found with ADD. The mean theta beta ratio for adults reported by Monastra was 1.49 and the cutoff of 1.5 standard deviations is 2.xx. Bernard had a theta beta ratio of 1.46 in the eyes open condition, slightly below the mean of 1.49. He had a typical pattern of increased alpha activity in the eyes closed condition and the theta beta ratio increased to 1.85. With reading, there was a modest decline in the theta beta ratio to 1.40 and the listening condition yielded a slight increase in theta beta ratio to 1.65. Given the short time frames, all of these readings are not statistically different and none of them shows any significant cortical slowing that could have contributed to his problems in sustained performance.

I discussed these findings with Bernard. I told him that there could be other brainwave patterns that might be linked to problems in concentration and attention, but that these would require a full 19 lead quantitative EEG to assess. I noted that a full QEEG would cost more than $700 and that I would have to refer him to another colleague as I did not have the necessary equipment and experience. I also told him that I could conduct a computerized test of sustained attention (the IVA plus) that could provide objective data regarding his ability to sustain focus and attention during a repetitive and boring task.

In addition, I also discussed the potential benefits of peripheral biofeedback training to enhance relaxation skills and lower arousal. I noted that we could expect to obtain benefits from peripheral biofeedback in 8–12 sessions and that most neurofeedback training requires considerably more sessions. We reviewed the similarities and differences between peripheral and EEG biofeedback and Bernard decided to proceed with the peripheral training.

Interventions and Results

The biofeedback training was provided with a Nexus-10 system running BioTrace software. In all sessions I used the following sensors: a blood volume pulse (BVP) sensor to monitor relative blood flow and heart rate, a respiration belt with a strain gauge to monitor abdominal movement, skin conductance sensors and a thermistor to measure finger temperature. The skin conductance sensors were placed on the middle phalanx of the second and fourth fingers of the nondominant (left) hand with the thermistor taped to the middle phalanx of the third finger. The BVP sensor was placed on the middle finger of the right hand. The training was conducted with the patient seated in a reclining armchair with the feet elevated.

In the first session we included two channels of surface EMG to monitor muscle tension in the head, neck, and shoulders. The placements were a modification of the frontal posterior neck placements first used by Mark Schwartz. One active electrode was placed on the forehead above the lateral aspect of the eye with the second electrode placed midway between the neck and the shoulder. A second pair of electrodes was placed at the same sites on the contralateral side. This arrangement is a wide, nonspecific placement that is sensitive to muscle tension from anywhere in the pericranial area. The bandwidth was set from 80 to 500 Hz to minimize EKG artifacts. Because the electrodes are so widely spaced baseline levels are higher than with frontal placements and I usually train to keep EMG levels below 8 microvolts at first, with a secondary target of below 5 microvolts. Bernard had low levels of EMG activity for most of the session and we did not include EMG monitoring in subsequent sessions.

The BioTrace software includes full support for dual monitors and I used a two display protocol in which the client viewed a monitor with simple training screens. My therapist screen included displays from all of the sensors and also permitted me to adjust settings and thresholds for the client display. Each of the sessions began with a baseline period of about three minutes in which the client display was a no feedback screen of a scene with rippling water.

I often start training for new clients with EMG feedback. I use EMG because it is easy to follow for the clients and serves as a good introduction. Clients can shrug their shoulders or clench their jaws and immediately see the changes in the EMG displays. Training to reduce EMG is often fairly straightforward and success at reducing EMG levels can inspire confidence when starting with other modalities that are less accessible to direct manipulations.

With Bernard, I decided to skip the initial EMG training because his muscle tension levels were already quite low. In fact, his overall baseline levels were quite low in terms of arousal (see Figures 7.2 and 7.3). Skin conductance readings fell from 4.17 to 2.09 and averaged 2.79 during baseline. In addition, his fingertip temperature

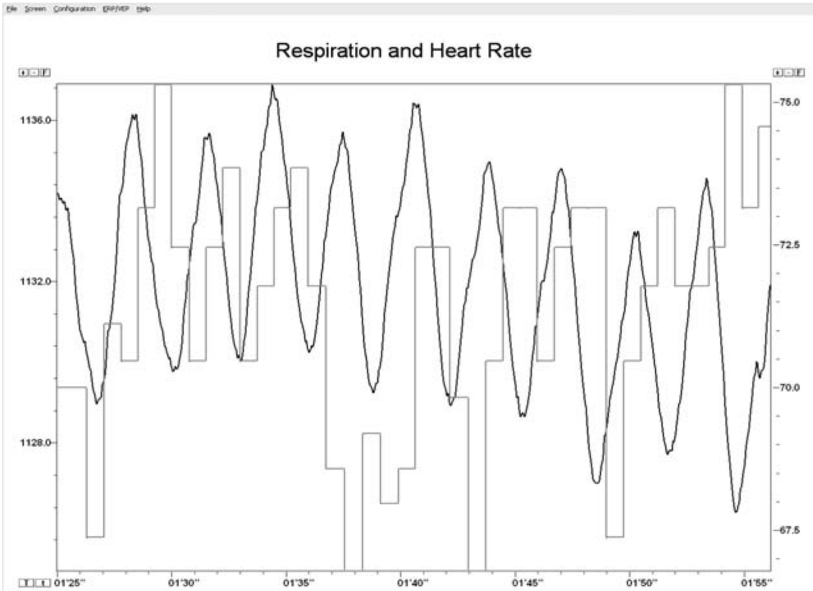


Figure 7.1 Respiratory effort (dark line) and heart rate (gray line), baseline, day 1.

was almost 97 degrees F, among the highest readings I have seen in many years. Respiration rate was almost 20 breaths/minute and I decided to start with breathing training with an intention to improve heart rate variability (see Figure 7.1).

The first training component used a paced breathing client screen running at 7.5 breaths/minute. The screen has a dual line graph on the upper half of the display

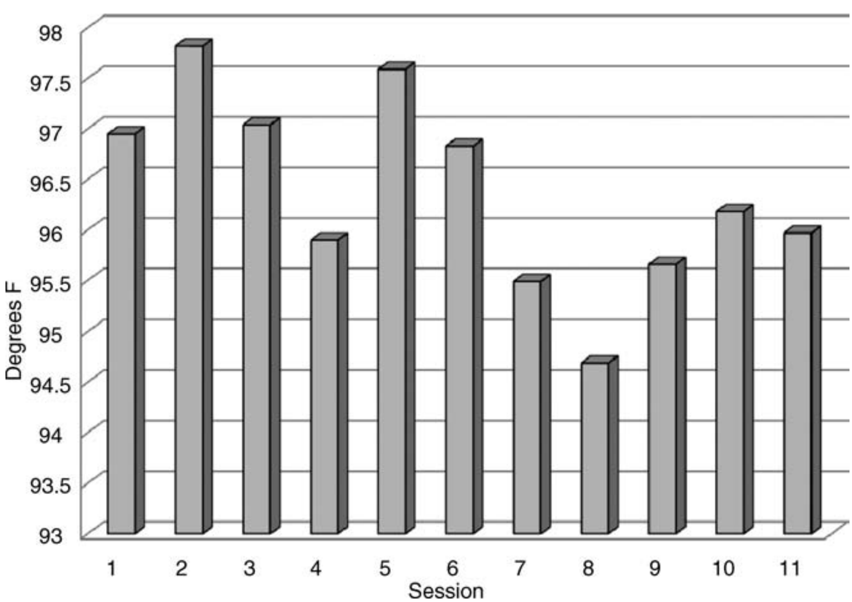


Figure 7.2 Temperature data across sessions.

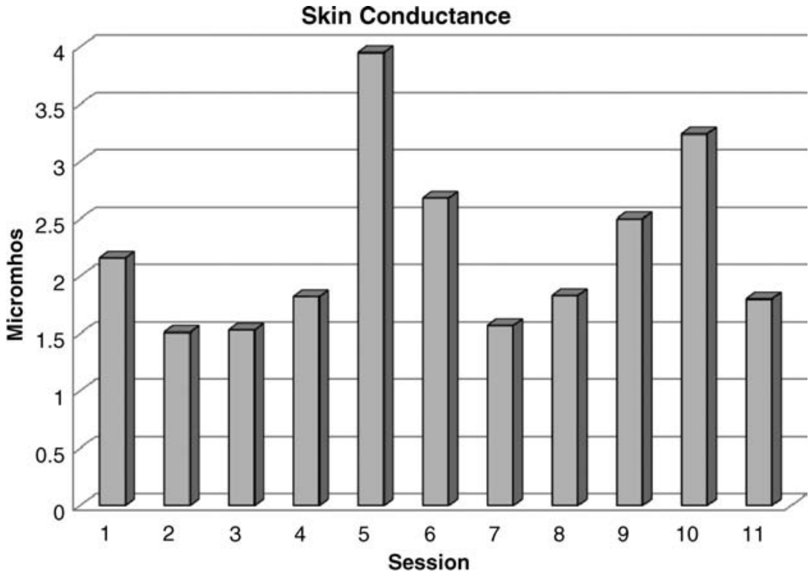


Figure 7.3 Skin conductance readings across all sessions.

and presents a yellow line that is controlled by the computer and a tracing of respiratory effort in green. The display also includes another line graph of heart rate and four numerical displays that present the paced breathing rate, the actual breathing rate, the current low frequency percentage (LF%) from the inter beat interval spectral analysis and the heart beat range over the previous 15 seconds. Music is presented when the LF% is above threshold. The computer controlled yellow line depicts the pacer signal and is modified sine wave. The respiration cycle includes a 50 msec pause after inhale and a 250 msec pause after exhale. The inhale time is set to 40.5% of the total cycle time and the exhale time is 55.7% of the cycle time. Bernard was instructed to breathe along with the yellow line, inhaling as it rose and exhaling as it fell.

The dual line graph, paced breathing screen is very effective in teaching clients to breathe more slowly and diaphragmatically, but it is not without problems. The computer controlled pacing line is consistently smooth and invariant. Clients often feel some pressure try to make the line displaying abdominal movement a perfect match rather than focusing on breathing in a slow and relaxed manner. I cautioned Bernard, as I do all of my clients, not to be too concerned about making the lines match perfectly, but to focus instead on breathing rhythmically and easily.

The paced breathing at 7.5 breaths/minute ran for three minutes and was followed by paced breathing at 7.0, 6.5 and 6.0 breaths/minute with a rest period after each training period. Bernard did quite well in all of the training periods and he did not report any difficulties while doing the paced breathing. I decided to conclude the session with an HRV training screen that did not include any pacing signals. The screen has an animation of a flower that can open or close set against a background of a star-filled sky. To the right of the flower is a small bar graph labeled “HR Rhythm” that tracked the LF%. A threshold of 65% was set and as long as the LF%

was above threshold the animation would move to the fully open state and gentle music would be presented. If the LF% reading fell below 65% for more than 0.5 seconds then the flower would start to close and the music would cease. When LF% is consistently above threshold, the animation remains in the fully open state and the music plays without interruption. Bernard remained above threshold for all but a few seconds and averaged 86.3% for his LF% over almost four minutes of training.

Bernard returned for four additional sessions over the next two weeks. Most of these sessions focused on HRV training, although I did some pulse amplitude training at times. In the second session I conducted a resonance frequency analysis. This is a procedure in which breathing is paced at various rates and a number of parameters that measure heart rate variability are calculated; the goal being the determination of the specific heart rate the supports the most consistent and deepest variability for that individual. For Bernard, the resonance frequency was 6.0 breaths/minute (see Figure 7.4).

Bernard did well in these early sessions. He was able to breathe consistently at paced rates of 5.5, 6.0, or 6.5 breaths per minute. Fingertip temperature was consistently in the mid 90s or better, and skin conductance readings were stable and relatively low. The only measurement that was not in the expected range was the blood pulse volume. Blood pulse volume is a relative measure, like skin conductance, so it is difficult to interpret differences across clients and sessions. However,

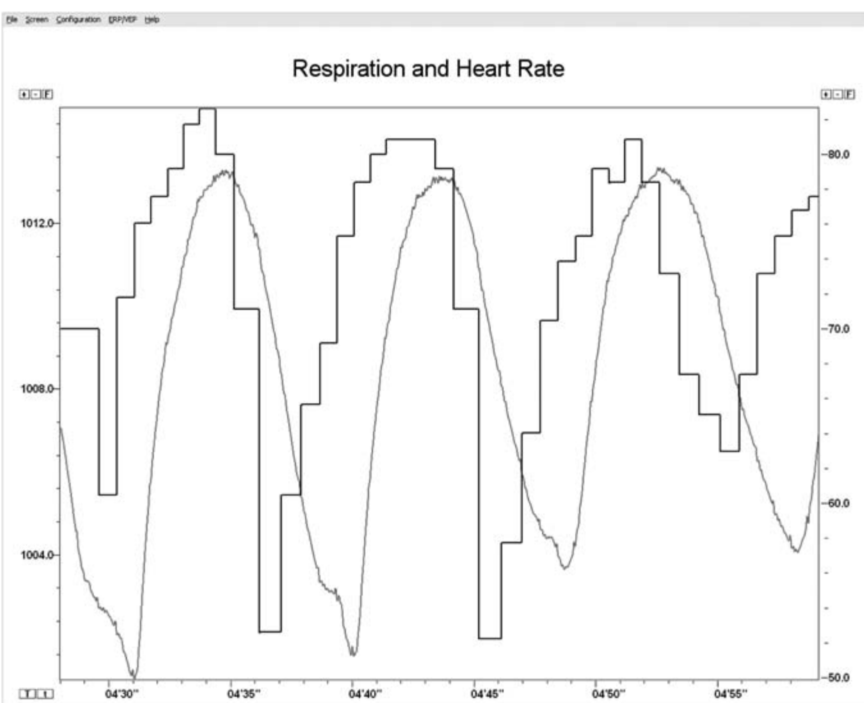


Figure 7.4 Respiratory effort and heart rate Day 2, pacing at 6.0.

Bernard's readings were consistently below 25 and there was minimal variability within sessions. Typically, a reading this low is consistent with moderately high levels of vasoconstriction and fingertip temperature is low. Bernard consistently had warm hands and the only explanation that occurred to me was that the readings were lower because of relatively large fingers.

It was gratifying to note improvement in Bernard's daily life after we started the biofeedback training. While I did not obtain any objective measurements to document changes, in each session we discussed how things were going on a daily basis. Bernard reported positive changes in many areas. He was generally calmer and more relaxed. He was able to deal with difficult situations more effectively and rarely lost his temper. The biofeedback training appeared to be a catalyst for change and Bernard spoke of his desire start exercising regularly and to lose weight.

We waited two weeks to schedule the sixth appointment and eventually completed a total of 11 biofeedback sessions with the last six sessions spread over a five-month period. This was a nearly ideal schedule as it gave Bernard ample opportunity to refine his relaxation techniques with home practice and still provided feedback sessions often enough to enhance his self regulatory skills. Most of the sessions consisted of a mix of paced and nonpaced breathing screens. The screens without pacing provided feedback for either increased LF% or increased HRV amplitude. Bernard did quite well for the most part and usually kept the feedback active for most of the training components.

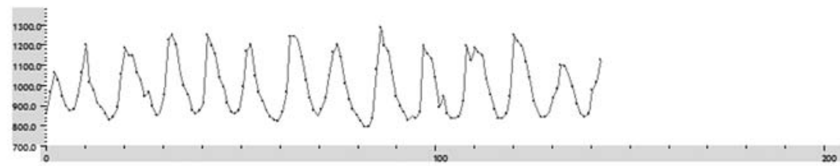
Respiratory patterns were fairly consistent within sessions and breathing rates were usually a bit slower than in the paced components. In sessions six and seven, the mean respiratory rate in the nonpaced components was 4.6 breaths/minute, with a range from 3.4 to 6.6 bpm. Over the final four sessions, respiration rates in the nonpaced training components ranged from 3.9 to 5.9 breaths/minute. HRV was generally strong and the LF% readings for the final five sessions ranged from 77% to 90% with SDNNs ranging from 56 msec to 143 msec. Figure 7.5 presents a typical power spectrum of the inter-beat intervals from the final training session.

At the time that I worked with Bernard I used feedback for LF% or HRV amplitude (15 second heart rate range) exclusively. I did not concern myself with the coherence between the heart rate and respiration patterns. The respiration/heart rate coherence variable is sensitive to the phase shift between the heart rate and respiration signals. When the breathing and heart rate vary together and the peaks and troughs of the two curves line up, coherence readings are high, approaching a maximum of 1.0. If the heart rate pattern either leads or lags the respiratory signal, then the peaks and troughs will be offset and the coherence values will be lower. Some of the leading clinicians in the field have come to emphasize maximizing respiration/heart rate coherence when conducting heart rate variability training.

The BioTrace software stores raw data and it is possible to review stored sessions and conduct post hoc analyses. I examined data from the final five sessions and obtained coherence values for the nonpaced sessions. There was a strong relationship between the respiration rates and the coherence levels. When respiration rates

Heart Rate Variability Analysis. *HRV channel 33:HR (BVP). 128 Samples/Sec.*

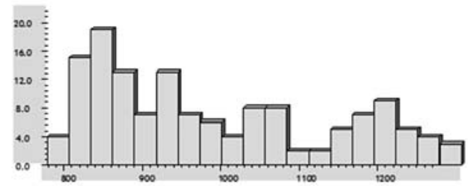
Graphical overview of the RR Intervals (IBI table)



HRV Statistical Results

Statistic	Unit	Value
NNMin	(ms)	797.00
NNMax	(ms)	1290.00
NNMean	(ms)	988.99
SDNN	(ms)	134.80
RMSSD	(ms)	96.55
NN50	(count)	67
pNN50	(%)	47.18

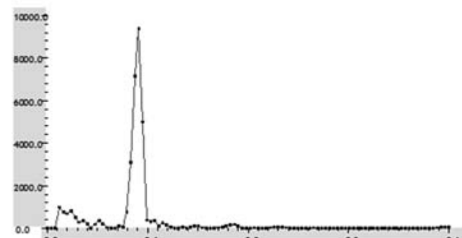
IBI Distribution



HRV FFT Results

Frequency	Unit	Value
VLF power	(ms^2)	4409.7
VLF %	(%)	12.62
LF power	(ms^2)	28604.8
LF %	(%)	81.88
HF power	(ms^2)	1919.4
HF %	(%)	5.49
LF/HF	(ratio)	14.9
LF Peakfreq.	Hz	0.090
LF Breaths/Min.	BPM	5.4

HRV Spectrum



Artifacts: 0.0% of the IBI data (0 beats out of 142) were rejected.
Note: The HRV Spectrum (0-0.4Hz) uses a non parametric FFT (1024 points) on detrended RR intervals, interpolated at 4Hz.

Figure 7.5 Day 11 HRV Power Spectrum from an unpaced training period to increase LF%.

fell below 5.5 breaths/minute, the coherence levels fell strongly. In sessions seven through nine, respiration rates ranged from a low of 3.9 to a high of 5.1 breaths/minute. The coherence readings were -0.71 at 3.9 bpm and -0.09 at 4.6 bpm. In session eight, respiration rates were 4.9 and 5.1 in two nonpaced components with corresponding coherence values of 0.10 and 0.21. In the final two sessions, the nonpaced respiration rates were between 5.6 and 5.9 breaths/minute and the coherence values ranged from 0.31 to 0.66.

It was interesting to note that some of the metrics of HRV were relatively unaffected at the slower respiration rates. The LF% readings were consistently high and even at 3.9 breaths/minute the LF% was at 89. The SDNN at 3.9 bpm was reduced (56 msec) but was strong at all other breathing rates (96–144 msec). If I had to do it over, I would have focused a bit more on keeping the breathing rates closer to 6 BPM, but Bernard seemed to work this out for himself and, as noted earlier, in the final two sessions the respiration were consistently between 5.6 and 5.9 breaths/minute.

Summary and Conclusions

This chapter provides a summary of biofeedback training with a middle aged man (Bernard) with fairly typical complaints – irritability, poor frustration tolerance, difficulties in focus and concentration, and a sedentary and generally unhealthy lifestyle. Training focused on improving respiratory patterns and increasing rhythmic heart rate variability, but other systems that were recorded included skin conductance (sweating) and fingertip temperature in all sessions and muscle tension from the head, neck and shoulders in the initial evaluation. These latter systems all showed low levels of arousal and we put our emphasis on breath control and HRV.

While the client was out of shape and obese, he had a history of being athletic in his youth and he quickly learned to generate consistent and strong heart rate rhythms. Mean heart rate was typically near 60 BPM, a relatively low resting heart rate for a non-athlete. Bernard did well at all paced breathing rates from 5.0 through 7.5 breaths/minute and we found a resonance breathing rate between 5.5 and 6.0 breaths/minute.

Bernard reported using the breathing techniques on a regular basis at home and at work. He was very pleased with the changes he noted. In general, he was more relaxed and calmer and he was able to cope with difficult situations better. He rarely lost his temper and got along better with other people. He stated that he felt that he was better able to manage his responsibilities at work and was less distracted. He also reported that he was eating a healthier diet and had returned to the gym to exercise regularly.

The weakness of this case study lies in the absence of objective data demonstrating the benefits of the biofeedback training. All of the information came from self reports and can be subject to distortion or selective recall. We also do not have information on sustained benefits, as I lost contact with Bernard and I do not know if he maintained the progress he reported. However, this is often the case in a clinical setting. I believe that the results obtained with Bernard are consistent with the benefits of biofeedback training that have been reported extensively over the past 40 years.

Reference

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8

Case 6 – The Road to Olympic Medal

Boris Blumenstein and Iris Orbach

Background Information

This story took place in 2003–2004 in Wingate Institute, Israel, with one of our best Judoka. There are a few reasons for choosing Judo as our case study for this chapter. Judo in Israel is characterized by unique circumstances such as the low number of strong competitors, low level of competition in training, and very hot climatic conditions most of the year; all these lead to the necessity of numerous trips abroad (Blumenstein, 2001). But notwithstanding all this, the first Olympic medals that were achieved by Israeli athletes were in Judo in 1992 (Barcelona) by Yael Arad and Oren Smadja. Since then, Judo came to be a very popular sport in Israel with many national and international achievements (European and world championships). In addition, professionals from this sport always cooperate with sport medicine departments, especially with sport psychology consultants. For example, Dr Blumenstein has been working with the national Judo team since 1992 and took part not only during training camps abroad, but accompanied the Judo team in numerous European and World championships and in the last four Olympic Games (i.e. Atlanta, Sydney, Athens, Beijing). These circumstances allow the consultant to get a close and intimate understanding of the athletes' lifestyles (i.e. norms, behavior, and mentality). For example, the Israeli Judoka athletes prefer variety of technical devices and concrete mental exercises that result in immediate outcomes which can be relatively quickly transferred from laboratory experience to real-life performance. Biofeedback training, which involves an electronic monitoring device and provides immediately visual and auditory feedback of physiological responses, has been suitable for athletes and can improve their mental skills such as relaxation,

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self-regulation, and self-confidence (Blumenstein, 2001; Blumenstein and Bar-Eli, 2005; Blumenstein, Bar-Eli, and Collins, 2002).

From 1991 our research team (Blumenstein, Bar-Eli, and Tenenbaum) focused on using biofeedback methods in numerous individual and team sports (e.g. Judo, swimming, windsurfing, rhythmic gymnastics, soccer, basketball). The research and the applied work with athletes led to the development of the Wingate 5-Steps Approach (W5SA) which includes Self-Regulation Test (SRT) and five steps to mental preparation with biofeedback (i.e. Introduction, Identification, Simulation, Transformation, Realization). This approach has been documented in numerous books and articles (e.g. Blumenstein, Bar-Eli, and Tenenbaum, 2002). Today, our consultant team has been developed integration between the W5SA and other intervention techniques such as imagery, relaxation, positive thinking, reaction training programs, and the implications of these complex strategies to athletic training. This relationship will be illustrated in our case study which will focus on a one-year work with one of the best Judoka athlete in Israel.

Athlete

The athlete was a Judoka (category of 100 kg), European champion and medalist in world championship and numerous international tournaments (category "A"). In the Olympic Games in Sydney 2000, he also competed and did very well. We will use the alias "athlete" to refer to our client. The athlete can be described as a professional from all aspects: High motivation, mental toughness, goal-oriented, high intelligence, and good cooperation with sport psychology consultant. We chose the one-year period of 2003–2004 including the Athens Olympic Games because during this phase the athlete suffered a few injuries which required special attention from the sport medicine staff including the sport psychology consultant. In addition to health problems, the athlete experienced unstable motivation and low self-confidence with no clear sport future. Dr Blumenstein worked with the athlete since 1993 and developed mutual strong relationship with the athlete and his personal coach. In order to provide the athlete with effective consultation in the laboratory, Dr Blumenstein was presented in the Judo Hall during practice at least once per week, observed athlete's behavior and performance, interacted with the coach, and accompanied the athlete in numerous training camps (e.g. Japan, Austria, Germany) and competitions.

Sport-specific background

The Judoka performs in a dynamic situation which demands various uses of cognitive processes, such as perceiving the environment, anticipating the acts made by the opponent, making a decision, and executing the planned act (Williams, Davids, and Williams, 1999). These processes should be executed within extremely short periods of time, namely 100 or 200 msc. The Judoka competes with an opponent who has the same goal of winning the 5 min combat. Therefore, it is not an easy task for the Judoka to simultaneously attack and defend while concealing his intentions from the opponent. While in an extreme state of tension, it is challenging for the Judoka to make decisions under time pressure while facing aggressive opponents and to decide on alternative tactical movements (i.e. attention flexibility) – all while striving to achieve the designated goals (Blumenstein, Lidor, and Tenenbaum, 2005). In summary, activities in Judo require quick responses as well as high level of attention, self-control, consistency, and will power (Pedro and Durbin, 2001).

An annual training program for Judo includes Preparation, Competition, and Transition Phases. The Preparation Phase is composed from General Preparation (GP), which lasts about 15 weeks, and Specific Preparation (SP) which lasts about 16 weeks. The main objective of GP is to improve the Judoka's working capacity, strength, and endurance – all elements required for Judo (Blumenstein *et al.*, 2005). The main objective of SP is to further develop the Judoka's physical ability according to the unique demands of Judo.

During the Preparation Phase the Judoka perfects his technical skills by participating in four or five training sessions of a medium intensity level per week, each lasting 90–120 min. The Judoka executes a variety of technical elements that help him improves his defensive and offensive combat skills. Among the psychological techniques used during the preparation phases are relaxation, imagery incorporating biofeedback, and self-talk. The objective of the psychological preparation during the Preparation Phase is to enable the Judoka to realize the benefits he can gain from appropriate implementation of psychological techniques. During this phase our athlete came to the laboratory once per week for a mental training which lasts 50–60 min. During that session he worked on the second step (i.e. Identification) of the W5SA, which its main goal is strengthening the most efficient biofeedback (BFB) response modality. Before and after this step the athlete is asked to perform self-regulation test. All psychological interventions have been provided with EMG, GSR channels which is more suitable for combat sports (Blumenstein, 2002). Biofeedback training was incorporated with relaxation and concentration exercises. Moreover, home exercises such as short relaxation (5–10 min) with portable GSR devices for strengthening his psychological skills were provided.

During the Competition Phase in Judo, the intensity of practice increases; however, the number of the repeated acts substantially decreases. The Judoka is exposed to a variety of actual environmental factors related to combat situations (Blumenstein *et al.*, 2005). In this respect, the psychological techniques are practiced within the 5 min time limitations of the combat. During this phase, emphasis is made on the actual use of psychological techniques during combat-simulated sessions. The objectives of the psychological techniques administered in this phase, such as biofeedback training, relaxation, imagery, and self-talk, are not only to assist the Judoka to prepare himself for the combat, but also to recover from the combat. For example, the length of the relaxation techniques is varied from 1 to 10 min so that the Judokas can use them during warm-up sessions before combat, as well as in break periods between combats. Video simulations of combats or fragments of combats during the competition period are used in both laboratory and training conditions. The simulations are combined with psychological techniques such as imagery (e.g. imagining successful performance), attention-focusing on relevant cues before and during the fights, and self-talk before, during, and after the fights. In this period, we trained on the third, fourth, and fifth steps of the W5SA – "Simulation" (i.e. Biofeedback training with simulated competitive stress), "Transformation" (i.e. proceeding preparation from laboratory to field), and "Realization" (i.e. applying the previously acquired mental techniques during competition). Our athlete was already familiar with the first two steps of the W5SA from our previous mutual work, therefore it was not necessary to start the training from the first step or to work on all five steps together. The athlete completed the SRT before and after the steps. Biofeedback training was accompanied with relaxation, imagery, and reaction time program (RTP) (Blumenstein *et al.*, 2005). During this phase athlete came to laboratory twice per week in which one session lasts 50–60 min. Moreover, short home exercises with portable GSR devices were provided.

The Transition Phase in our case lasts about 4 weeks, and during this time the Judoka is asked to maintain a low level of physical activity. Psychological recovery techniques are implemented, such as relaxation with special music, breathing exercise, and biofeedback training. These techniques were combined with medical treatments such as physiotherapy and massages. The objective of the psychological and medical techniques is to assist the Judoka in recovering after competition (Blumenstein, Lidor, and Tenenbaum, 2007). During this phase athlete came to laboratory once per two weeks in which one session lasts 40–50 minutes. A detail typical annual and weekly psychological training plans for Judo in each Preparation Phase is described in the book *Psychology of Sport Training* (Blumenstein *et al.*, 2007).

Summing up what we said previously, our focus was on improving the athlete's psychomotor and self-regulation ability, his confidence and subsequent performance in numerous important competitions of the year such as European Championship and two International tournaments category "A." Our intentions were to use those events as a simulation and models to the future Athens Olympic Games.

Intervention, Equipment, and Measurements

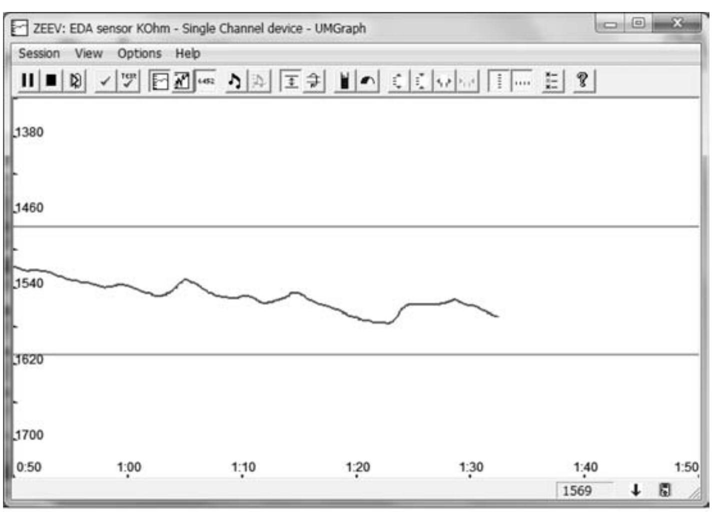
As part of our training SRT was provided before and after each step of the W5SA. The treatment took place in sport psychology laboratory, which included Mindlife biofeedback device (i.e. ProRelax by Mindlife Solutions Ltd.) and monitors skin conductance via two 5-mm-diameter electrodes connected with velcro bands. The electrodes are connected to a sensor box and the row data is transmitted via IR connection to the receiver box. The isolated skin conductance coupler applies a constant 0.5 V potential across the electrode pair. The sample rate is 10 samples per second. The hardware measures the resistance and creates the EDA units using 14 bits and providing actual range of 10,000. EDA units can be converted into kilo ohms (GSR) (see Table 8.1).

Table 8.1 Formula to convert EDA units to kilo ohms.

	Coefficients			
EDA Value	*a(0)*	*a(1)*	*a(2)*	*a(3)*
0–4499	1075.706	−0.9766399	0.0002684	−2.24E-08
4500–8999	−341.5146	0.1234316	−0.0000139	1.57E-09
9000–10099	25.4547	0.0737562	−0.0000189	2.26E-09
10100–12499	−37436.9	11.10762	−0.0011063	3.81E-08
12500–14399	−25880	2.2993	0	0
$\mathbf{Kohms\ (EDA) = \sum a(i)^{*}(EDA)^{i}}$				

Note: The resistance varies from 75 Kohms to 7 Mohms (mega ohms).

In Figure 8.1, a basic graph with GSR data is presented. The feedback is provided in visual and auditory form and can be offered to athletes in graphs, barometer, and meters. Another piece of equipment is the I-330 by Atlas Ltd, which includes physiological monitoring system consists of EMG, GSR and HR channels. The EMG measures (in microvolt) are provided with the surface EMG electrodes on the frontalis (forehead) muscle, following Kondo, Canter, and Bean (1977). The ground electrode may conveniently be placed between the two active electrodes. The EMG was measured using averaged peak-to-peak micro voltage (p-p μV) values of EMG activity for determined sample times. Moreover portable biofeedback devices includes Mind Master[801] and Stress Master[802] by Atlas Ltd (skin response monitors, reflecting the variations in sweat gland activity) used for



Note: The two horizontal lines are boundaries to the range in which the athlete has to stay during a two minutes concentration exercise. The range can be changed by the consultant based on the specific mental goal and exercise.

Figure 8.1 Graph with boundaries, vertical axis in Kohm and horizontal axis in minutes.

homework, practice, and competitions. Other equipment devices include two sets of TV-VCR camera system, video camera recorded (VCR), musical center and comfortable reclining chair.

During the first mental session of the Preparation Phase the athlete undergoes SRT to examine his baseline self-regulation level before the mental training program is applied (Blumenstein, Bar-Eli, and Collins, 2002). Essentially, the SRT consists of four elements: Rest, tension, relaxation and competition. After recording the athlete's psychophysiological base line (HR, GSR, EMG) the athlete is asked to imagine himself in laboratory setting under four states: resting, tense, relaxed, and competition. During each of these imagery phases which last about 2 min each, the athlete's psychophysiological responses (HR, GSR, and EMG) are recorded to indicate the type of alteration in each response modality as well as its relative intensity. The sport psychologist notes the direction and intensity of the observed changes. However, in order to establish the unique pattern that characterizes each and every athlete, the relations between the various psychophysiological indices (with regard to direction and intensity), as well as the relations within and between the imagery phases, should be analyzed. Based on 15 years of experience and application of our program in Judo, elite athletes should achieve the following results in SRT before main competition which characterize their self-regulation level:

- High self-regulation level: 11–12+ (positive changes in HR, GSR, EMG channels × 4 states) which indicates on high self-regulation abilities (maximum possible results is 12+)
- Average self-regulation level: 8–10+ indicates on average self-regulation abilities
- Low self-regulation level: 6–7+ indicates on low self-regulation abilities.

In the first session the Judoka achieved 7–8+ (see Table 8.2) while the dominant responses were HR and EMG, which characterize an athlete who come back from Transition Phase. He did not react to the GSR channels on the four states of the SRT. In Judo EMG and GSR responses in SRT are the most dominant biofeedback modality (Blumenstein, 2002).

Table 8.2 SRT before preparation phase.

		Rest			*Tension*			*Relaxation*			*Competition*		
	Baseline	*B**	*A**	+	*B*	*A*	+	*B*	*A*	+	*B*	*A*	+
HR bpm	70	72	66	+	70	72	−	72	66	+	67	76	+
EMG μV	2.7–2.8	2.8	2.1	+	2.6	3.0	+	2.7	2.0	+	2.4	3.1	+
GSR kΩ	650–670	668	690	−	681	670	−	690	650	−	690	610	+

B* = Before; A* = After

Note: In HR and GSR modalities the athlete received + when a change of 10% in his responses was observed; In EMG modality a + was received when a change of 20% was observed.

During the Preparation Phase we focused on the following BFB training together with psychological interventions:

- Concentration exercises with GSR BFB: 10 sec × 5 times
- Relaxation exercise with EMG/GSR BFB: 1 min × 10 times
- Relaxation with EMG/GSR BFB with music: 10 min
- Relaxation-excitation exercise (waves) with EMG/GSR BFB: 20 sec × 2–3 times
- Self-talk and positive thinking: 10 sec × 5 times
- Imagery with EMG/GSR BFB: 5 min
- Reaction training program 10–20–20 × 2 times.

The following is a typical protocol of a mental session during the Preparation Phase which was conducted after the SRT.

Protocol I

Place: Sport Psychology Lab, Wingate Institute
Day: Monday, February 2003
Time: 13:00–14:00

Introductory part: Developing motivation and positive thinking
Main part:

- Attention-focusing exercises, 20 sec × 3–5 times with GSR BFB (good results: Δ 50–70 kΩ during 20 sec)
- RTP 10–20–20: 10 (simple)–20 (choice)–20 (discrimination) × 2 times (a main goal to achieve in simple reaction: $M = 165–170$ msc, $SD \pm 70–80$; in choice reaction: $M = 175–180$ msc, $SD \pm 70–80$; and in discrimination reaction: $M = 170–175$ msc, $SD \pm 70–80$). In addition, we take into account the balance between "fast" (<200 msc) and "slow" (>200 msc) reactions which characterize the quality of this exercise. For example, the goal for these exercises was 6/4 and at the end of the Preparation Phase 9/1 (i.e. "fast"/"slow"). Specific details describing this program can be found in Blumenstein and Weinstein (2010)
- Relaxation-excitation exercise (waves) with EMG/GSR modalities: 20 sec × 2–3 times
- Imagery which focus on a match between our Judoka and possible opponents from Europe. In each mental session we focused on a different opponent.

Final Part: Muscle relaxation with EMG BFB accompanied with special relaxation music 5–7 min.

During Preparation Phase the athlete came to only 19 mental sessions since the Judo team was abroad for long periods. The sessions took place in laboratory setting, using the GSR and EMG BFB. After 4–5 meetings the Judoka achieved the above goals in laboratory sterile conditions. The modifications to the above protocol were in the demands, the situations, and the difficulties during performance. For example, demands of performing RTP with balance 9/1 which means that during

Table 8.3 SRT before competition phase.

	Baseline	*Rest*			*Tension*			*Relaxation*			*Competition*		
		B	*A*	+	*B*	*A*	+	*B*	*A*	+	*B*	*A*	+
HR bpm	68	66	60	+	62	70	+	64	62	−	66	76	+
EMG μV	2.6-2.4	2.4	1.4	+	1.9	3.2	+	2.6	1.2	+	2.4	3.6	+
GSR kΩ	610-630	610	720	+	690	640	−	640	810	+	660	360	+

Note: In HR and GSR modalities the athlete received + when a change of 10% in his responses was observed; In EMG modality a + was received when a change of 20% was observed.

simple, choice, and discrimination reaction time the Judoka can make only 1 mistake or "slow" reaction per each exercise. The Judoka performed the exercise with external positive (e.g. "you are strong today") or negative (e.g. "you cannot perform the exercise") comments and motivation. Moreover, the Judoka improved his self-regulation skill in exercise relaxation-excitation waves. This exercise includes relaxation (EMG from baseline 2.2–2.4 μV to 0.8–1.0 μV) and excitation (EMG from 0.8–1.0 μV to 3.2–3.4 μV) during time period of up to 20 sec, repeating the wave 3 times. More specific details about the exercise variations and difficulties in combat sport are in Blumenstein and Weinstein (2010). We began the next phase, the Competition Phase, in SRT.

From Table 8.3, it can be observed that the Judoka experienced more drastic changes, while the EMG and GSR are the more dominant modalities which characterize combat sport. In the previous phase the Judoka achieved 8+ from 12+ maximum, while in this phase the Judoka achieved 10+ from 12+ maximum.

During the Competition Phase we focus on the following BFB training together with psychological interventions:

- Concentration exercises with GSR BFB: 20 sec × 5 times with different simulations and difficulties; 30 sec × 5 with simulations difficulties (see Blumenstein and Weinstein, 2010)
- Relaxation exercise with EMG, GSR BFB: 30 sec × 8–10 times; 1 min × 5 times; 3 min × 5 times; 5 min × 5 times
- Relaxation with EMG/GSR BFB with music: 10 min
- Relaxation-excitation exercise (waves) with EMG/GSR modalities with VCR impact: 20 sec × 2–3 times
- Self-talk and positive thinking oriented on quick relaxation and concentration: 10 sec × 5 times
- Imagery with GSR BFB and VCR impact (competition sound and fragments): 5 min × 2 times
- Reaction training program 10–20–20 × 2–3 times with VCR impact and special demands during performance.

The following are typical protocols of the mental sessions during the Competition Phase which were conducted after the SRT. During this phase the Judoka met with the sport psychology consultant twice a week (i.e. Monday and Thursday). The goal of the Monday meeting was improving psychomotor abilities while focusing on RTP and different concentration exercises (Protocol 2). The goal of the Thursday meeting was improving imagery and relaxation skills (Protocol 3).

Protocol II

Place: Sport Psychology Lab, Wingate Institute
Day: Monday, March 2003
Time: 13:00–14:00

Introductory part: Analyzing past week and developing motivation and goal setting according to the current training situation.
Main part:

- Attention-focusing exercises with GSR BFB channels, 20 sec × 3–5 times (good results: Δ50–70 kΩ during 20 sec) and different difficulties (e.g. positive and negative motivation and verbal instructions).
- RTP with VCR impact: 10 (simple)–20 (choice)–20 (discrimination) × 3 times (main goal was to achieve in simple reaction: $M = 150–155$ msc, $SD \pm 30–40$; in choice reaction: $M = 165–170$ msc, $SD \pm 30–40$; and in discrimination reaction: $M = 150–155$ msc $SD \pm 30–40$). In addition, we take into account the balance between "fast" (< 200 msc) and "slow" (> 200 msc) reactions which characterize the quality of this exercise. For example, the goal for these exercises was 9/1 and at the end of the Preparation Phase 10/0 (i.e. "fast"/"slow"). Specific details describing this program can be found in Blumenstein and Weinstein (2010).

Final part: Muscle relaxation with EMG BFB accompanied with special relaxation music 5–7 min.

The second meeting on the same week is presented below:

Protocol III

Place: Sport Psychology Lab, Wingate Institute
Day: Thursday, March 2003
Time: 13:00–14:00

Introductory part: Analyzing current mood and focus on positive training results.
Main part:

- Attention-focusing exercises with GSR BFB channels, 10 sec × 3–5 times. The goal is to achieve quick concentration level which prepared the athlete for the next imagery part
- Relaxation-excitation exercise waves with EMG/GSR BFB modalities with VCR impact (i.e. competition noises and competition fragments): 20 sec × 2–3 times
- Imagery which focused on a match between our Judoka and possible opponents from Europe accompanied with VCR impact, competition noises, and competition

fragments. On each mental session we focused on a different opponent. In addition, during the imagery the Judoka gave a signal with his fingers when he attacked. We analyzed each minute during the 5 min fight using imagery and his GSR reaction during imagery. Usually, the Judoka imaged his fight with 77–100 kΩ. Before European championship (May 2003), we analyzed all of his main competitors and strengthened his technical-tactical performance in mental session. Based on his remarks, we significantly improved his self-confidence.

Final part: Muscle relaxation with EMG BFB accompanied with special relaxation music 5–7 min.

During the Competition Phase we provided 18 mental sessions in laboratory settings and 6 sessions in practice in Judo Hall. We focused on concentration in warm-up, relaxation and imagery during pauses between fights, and relaxation at the end of the practice. In addition, two mental sessions in laboratory settings were provided with "double-feedback" procedure (Blumenstein *et al.*, 2002), which includes traditional BFB linked with behavioral feedback (i.e. using a video camera in order to film the athletes' facial expressions). The aim of this "double-feedback" procedure is to facilitate facial self-regulation. This is crucial not only to enable the athlete to better control his own emotional side through regulation of facial expression during competition, but also for competitive purposes such as deceiving the rival.

The main goal of the Transition Phase is physical and mental recovery. Therefore, the frequency of our meetings was once per two weeks. During this meeting we worked on developing positive motivation and goal setting for the next competitive season; relaxation with GSR and EMG BFB accompanied with music were provided during 20–25 min. Moreover, the Judoka performed different relaxation games with GSR BFB such as the fish game (see Figures 8.2 and 8.3). In this dynamic game the

Figure 8.2 A picture from the "Fish" game.

Figure 8.3 A picture from the "Fish" game (*continued*).

athlete uses relaxation and concentration skills in order to move the fish forward from left to right side and to transform the picture to other forms such as mermaid and finally a woman. In addition, the sensitivity of the game can be changed from 1 to 10 (i.e. difficult–easy).

The "fish" game is accompanied with special relaxation music. Usually, best elite athletes performed this game during 1:30–1:45 seconds with sensitivity 5. The same animated principle is used in other BFB games of the ProRelax program using themes such as flight, history, and nature.

Results and Discussion of Findings

There are important points that should be considered when analyzing this case study. First, the Judoka already had extensive experience in mental training, especially in BFB training, therefore his attitude was positive during our meetings. He understood that the mental training is a part of his general training preparation. Second, BFB training, based only on three steps of W5SA and their combinations, was part of mental intervention package including relaxation, imagery, self-talk, reaction-time program, and music. This program was developed based on a specific rational, structure, and order which was suitable to combat sport and specifically to Judo. In addition, the mental intervention package was part of the overall Judoka's training program which included physical, technical, and tactical preparation. Third, this program takes into account the Judoka's current physical, medical, and mental state (i.e. recovering from injuries, improving self-confidence, self-regulation, and psychomotor abilities). Fourth, a major reason to the success of this program was the good relationship among the athlete, the personal coach, and the sport psychology consultant.

During the mental training program the Judoka improved his concentration, self-regulation, and self-confidence according to our norms, difficulties of the exercises, and behavior during the mental sessions, practice, and competitions. In general, we required that the athlete would perform all BFB exercises quickly and exactly. For example:

- SRT: improvement from 7–8+ to 10–11+ before European championship and Olympic Games (with relevant GSR and EMG responses which suitable in Judo)
- Concentration: delta 50–70 kΩ under sterile (i.e. easy) condition to 50–70 kΩ under difficult conditions such as competition noises, negative oral motivation, etc.
- Relaxation-excitation exercise (waves) with EMG/GSR modalities during 20 sec from baseline relax 0.8–1.0 μV (EMG) and then excite to 3.2–3.4 μV (EMG) (with VCR impact)
- RTP (with VCR impact):
  - from $M = 165–170$ msc, $SD \pm 70–80$ to $M = 150–155$ msc, $SD \pm 30–40$ in simple reaction
  - from $M = 175–180$ msc, $SD \pm 70–80$ to $M = 160–165$ msc, $SD \pm 30–40$ in discrimination reaction
  - from $M = 170–175$ msc, $SD \pm 70–80$ to $M = 145–155$ msc, $SD \pm 30–40$ in choice reaction
  - balance: from 6/4–7/3 to 9/1–10/0.

Positive change in his mental state was observed not only in the mental sessions but also during his training and fights. Two months before the European World Championship the Judoka admitted that he applied many of the mental skills to his practice, such as concentration before and during fights, relaxation and quick entrance to exercises during fights (i.e. the Judoka's reported "I am fast"). Therefore, the Judoka performed many ippons during one training match (ippon is the highest score, "one full point," a judoka can achieve in a match). Beyond any question, we understand that the Judoka's achievement cannot be attributed only to the mental aspect. It can rightly be said that the Judoka's success can and should be attributed to his physical, tactical, and technical preparation. However, the mental preparation was an integrated and important part of his training program.

The Judoka traveled to Dusseldorf, Germany to the European Championship (16–19.5, 2003) accompanied by Dr Boris Blumenstein who was the mental consultant for National Judo team at that time. In the following paragraphs we describe athlete's results from this competition.

May 18, 2003, Competition day: The first match was against Delahay Sam from England. The Judoka won the fight by ippon after 2:35 minutes. The second match was against Kovacs Antal from Hungaria (gold medalist from Barcelona, silver medal from World Championship, 2001). The Judoka won after 5:00 stressful minutes. The third match was against Mashurenko Ruslan (bronze medalist from Sydney, 2000) from Ukraine. The Judoka won by ippon after 0:46 min. The fourth match was against Makarov Igor from Belarus. The Judoka won after 5:00 minutes. The last match was against Van Der Geest Elco (European champion, 2002) from Holland. The Judoka won by ippon after 1:09 min. Finally, our Judoka achieved the first place!

This preparation model to the European championship was also applied in preparing for the Athens Olympic Games. During the Olympic Games our Judoka participated in the following matches: The first match was against Mario Sabino Junior from Brazil. The Judoka won by ippon after 4:52 min. The second match was again Michele Monti from Italy. The Judoka won by ippon after 4:14 min of a stressful and intense fight. The third match was against Sung Ho Jang from Korea. The Judoka lost the fight by ippon after 4:07 sec. The fourth match was against Moussima Ewane Franck Martial from Cameron. Our Judoka won the match after 5 minutes by two *waza-ari* (*waza ari* is the second highest score, "half a point," a judoka can achieve in a match). The next match was against Christian Lemaire from France. The Judoka won by ippon after 2:48 min. The match for Bronze medal against Elco van Der Geest from Holland repeated the last European championship. The Judoka won the match by ippon after 4:09 min and achieved a bronze medal for his country.

It is no exaggeration to say we were in seventh heaven with happiness. In his TV interview the Judoka said, "I am happy, thanks to all people who helped me, especially to my coach and to my mental consultant." When answering questions about his future plans he said, "I have good positive dynamics in my Olympic achievements: Sydney – 5th place, Athens – 3rd place, Beijing – ?," but that is a story for another case study.

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9

Case 7 – Biofeedback Training at Sea

Boris Blumenstein and Iris Orbach

Background Information

Our story took place on the white sandy beaches of the Mediterranean coast in the National Sailing Center in Sdot-Yam and the Wingate Institute. The sport we chose for this case is windsurfing, a very popular sport in Israel. Windsurfing is a relatively new Olympic sport (the first time was in the Los Angeles Olympic Games, 1984) and requires a special lifestyle and philosophy. Windsurfing training is a full-time job with three major aspects: improving racecourse management and tactics, perfecting equipment handling and sailing technique, and developing Ironman-level physical fitness. Windsurfing competitive performance involves high endurance and speed, and is regulated by the opponents and meteorological conditions throughout the entire race. Often waiting for suitable weather, decision-making speed and cognitive processes in different situations during race impact on athlete performance. Moreover, the windsurfer is required to conduct numerous starts within short time periods. For example, Olympic regattas consist of 16 races over 9 days, with two or three 45-minutes races (depending on wind conditions), each day of the competition. Most windsurfers and coaches admitted that mental control, mental toughness, and self-regulation are necessary for successful performance (Serpa and Rodriguez, 2001).

This case study describes one of the first attempts in our country where psychological preparation, including Biofeedback (BFB) training, was used in windsurfing. We will discuss our work with one of the best world windsurfer from an educational point of view, in which we focus on his mental and emotional aspects of performance enhancement. Our psychological program was based on the Wingate 5-Steps Approach (W5SA) (Blumenstein, Bar-Eli, and Tenenbaum, 2002)

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and was applied mainly with portable biofeedback devices in real life on the beach and in the sea.

Athlete

Our athlete was a young and successful windsurfer with 15 years' experience of training in the sport who became one of the best-known athletes in the country. The success of the athlete began when he was very young. He took part in numerous international competitions and championships. He liked long, hard training at sea and in the weight training hall. For years, his philosophy was perfectionism. He rarely took breaks from activities for more than 1–2 weeks during the training year and all the coaches knew that he was a hard-working athlete who believed that this was the only way to win. The athlete and his coach constantly searched for new ways, new ideas, new training technologies and methods. For example, they brought windsurfing equipment to the weight room and trained using different weights to improve his athletic physical condition while attempting to simulate real-life conditions. When we first saw the athletic training we were impressed by his training volume and his creativity.

Our work with the athlete began when he came to our sport psychological laboratory with a proposition. He said that he did not believe in psychological support. "I am at sea by myself with nature, the wind, and waves, and my decision-making during race is decisive in whether I win or lose. However, I heard from other athletes that you can help and possibly measure your impact on my performance. Do you have special equipment? I do not believe in paka-paka [i.e. slang, special words about nothing]."

Dr Blumenstein explained his psychological preparation approach, presented his lab equipment, and discussed with the athlete his demands and conditions. However, he could not give his concrete agreement and recommendation before he would observe training in the specific sport. After joining the athlete in a few practice sessions Dr Blumenstein agreed to work with the athlete. The conditions under which the work took place were very hard (e.g. sitting in the boat in the sea with the coach for 4–5 hours). During the one-month introductory phase Dr Blumenstein and the athlete became acquainted and found many cases in which he could benefit from psychological intervention. For example, relaxation and recovery after training or between races in competition; possible improvement and optimization of pre-start emotional state and self-regulation skills, especially 5–10 minutes before water start. Moreover, when we worked together we paid attention to the athlete's general behavior during the waiting period on the beach before the race. Sometimes in competition he was not emotionally stable: he continually checked his equipment, observed other windsurfers, and did not follow a pre-competitive routine.

Equipment, Assessment and Diagnosis

In this case study we use portable biofeedback device, the ProRelax by Mindlife Solutions Ltd and portable PC (IBM). Mindlife biofeedback device monitors

Table 9.1 Formula to convert EDA units to kilo ohms.

	Coefficients			
EDA Value	*a(0)*	*a(1)*	*a(2)*	*a(3)*
0–4499	1075.706	−0.9766399	0.0002684	−2.24E-08
4500–8999	−341.5146	0.1234316	−0.0000139	1.57E-09
9000–10099	25.4547	0.0737562	−0.0000189	2.26E-09
10100–12499	−37436.9	11.10762	−0.0011063	3.81E-08
12500–14399	−25880	2.2993	0	0
$\mathbf{Kohms}\ (\mathbf{EDA}) = \sum \mathbf{a(i)}^*(\mathbf{EDA})^{\mathbf{i}}$				

Note: The resistance varies from 75 Kohms to 7 Mohms (mega ohms).

skin conductance via two 5-mm-diameter electrodes connected with velcro bands. The electrodes are connected to a sensor box and the row data is transmitted via IR connection to the receiver box. The isolated skin conductance coupler applies a constant 0.5 V potential across the electrode pair. The sample rate is 10 samples per second.

The hardware measures the resistance and creates the Electro Dermal Activity (EDA) units using 14 bits and providing an actual range of 10 000. EDA unites can be converted to kilo ohms (GSR) (see Table 9.1).

Another item of equipment is the I-330 by Atlas Ltd, which includes a physiological monitoring system consisting of Electromyography (EMG), Galvanic Skin Response (GSR), and Heart Rate (HR) channels. The EMG measures (in microvolt) are provided with the surface EMG electrodes on the frontalis (forehead) muscle, following Kondo, Canter, and Bean (1977). The ground electrode may conveniently be placed between the two active electrodes. The EMG was measured using averaged peak-to-peak micro voltage (p-p μV) values of EMG activity for determined sample times. Moreover portable biofeedback devices includes Mind Master[801] and Stress Master[802] by Atlas Ltd (skin response monitors, reflecting the variations in sweat gland activity) used for homework, practice, and competitions.

Our intervention program was based on the W5SA and we began our mental training sessions with Self-Regulation Test (SRT) to examine the athlete's baseline self-regulation level (see Table 9.2) (more details about SRT can be found in the previous chapter (Chapter 8, Case 6: The Road to Olympic Medal).

Table 9.2 SRT during first mental session.

		Rest			*Tension*			*Relaxation*			*Competition*		
	Baseline	*B**	*A**	+	*B*	*A*	+	*B*	*A*	+	*B*	*A*	+
HR bpm	66	66	60	+	62	74	+	72	68	−	64	86	+
EMG μV	2.6	2.5	1.8	+	2.4	2.6	−	2.5	2.3	−	2.2	3.6	+
GSR kΩ	470	430	450	−	460	450	−	430	600	+	580	490	+

*B = Before; A = After.

Note: In HR and GSR modalities the athlete received + when a change of 10% in his responses was observed; In EMG modality a + was received when a change of 20% was observed.

In the first session, the windsurfer achieved 7+ in the SRT. In addition, we tested the athlete's concentration level with GSR modality in which the athlete was asked to concentrate and at the same time observed his GSR responses (i.e. for a good performance the red line on screen goes down about Δ 50 kΩ in 30 sec). Our athlete achieved this result from his first attempt. We used three modifications of this exercise: performance in regular-no-distractions situation, performance with negative/positive instructions, and performance with competitive noises. According to the phases of the W5SA, one of these modifications was applied. Moreover, Dr Blumenstein tested his relaxation abilities with EMG modalities from muscle frontalis. The athlete's results changed from baseline 2.4–2.6 μV to 0.6 μV during 3 minutes (good results). Dr Blumenstein asked the athlete about his strategies and difficulties in different meteorological situations (high/light wind, different wind directions, etc.). Based on this information we developed our special psychological interventions to this sport and specific athlete.

Intervention and Settings

After SRT and concentration/relaxation tests we continued our work in the laboratory setting with learning the W5SA (Blumenstein and Bar-Eli, 2005; Blumenstein *et al.*, 2002) as follows:

- Introduction which included learning self-regulation techniques such as imagery, self-talk, and focusing attention, lasting for 5 meetings in the lab
- Identification which included strengthening the most efficient EMG/GSR BFB response modality for windsurfing, lasting for 4 meetings in the lab
- Simulation which included BFB training with simulated stress, lasting for 3 meetings in the lab
- Transformation which included BFB training in the field, lasting for 10 meetings in Sdot Yam (boat and beach)
- Realization which included achievement of optimal regulation in several competitions.

W5SA was already described in the sport psychological professional practice literature (Blumenstein and Bar-Eli, 2005; Blumenstein *et al.*, 2002). A modification to the length of the program is needed based on the particular characteristics of the sport and the athlete. For example, in our case study the "Simulation" step was relatively short since it was almost impossible to simulate meteorological conditions in the lab. Other external factors which are typical to other sports such as media, fans, and coach interaction do not exist during windsurfing competition. Moreover, the "Transformation" step was relatively longer compared with the other four steps and was integrated into the athlete's regular training.

The following are typical protocols of the mental sessions in the first three laboratory steps: Introduction, Identification, and Simulation. The first learning step, the "Introduction," took place in a laboratory setting and lasted four sessions, in which each session lasted for 55–60 minutes, once a week. This step consisted of teaching the athlete to regulate his mental state through observing the psychophysiological responses on the screen. The goal of this learning phase is to achieve a stable process in which the windsurfer relaxes for about 1–2 minutes and concentrates for 10–20 seconds. The athlete learned very quickly with EMG/GSR BFB. We corrected him only 1–2 times in his relaxation-concentration process. The following is an example of the protocol of a psychological training session in the Introduction step.

Place: Sport psychology laboratory
Day: Monday
Time: 13:00–13:50

Introductory part: Developing sport motivation and positive thinking; attention-focusing exercises: 2–3 times × 10–20 sec.
Main part:

- Muscle relaxation with EMG BFB: 2 times × 2–3 min each
- Muscle relaxation with EMG BFB: 2 times × 1 min each
- Imagery (30 sec before water start and actual water start) with GSR BFB: 2 times
- Imagery (10 sec before water start and actual water start) with GSR BFB: 2 times
- Self-talk with EMG BFB for training in sea: 3 times × 1 min.

Final part: Relaxation with music for 10 min.

In the second step, "Identification," which included four sessions, the goal was to identify and strengthen the athlete's most efficient response BFB modality in terms of personal characteristics and the demands of his sport discipline. The athlete attempted to work with the relevant EMG/GSR modalities to windsurfing. According to Blumenstein (2002) and Blumenstein, Bar-Eli, and Collins (2002) these modalities reflect windsurfing performance which involves a high level of tactile and proprioceptive sensitivity, intense emotional involvement. In this step we worked on synchronized EMG and GSR responses in relaxation and concentration processes. Moreover, the athlete must be able to perform quickly, accurately, and reliably. The following is an example of protocol of a psychological training session in the Identification step.

Place: Sport psychology laboratory
Day: Monday
Time: 13:00–13:50

Introductory part: Positive thinking, attention-focusing exercises: 5 times × 10–20 sec each.
Main part:

- Muscle relaxation with EMG/GSR BFB: 5 times × 1 min each
- Imagery with "soft" eyes and EMG/GSR BFB:
  - 1 min before water start, water start, and 1 min best performance after start: 2 times

  - 30 sec before water start, water start, and 1 min best performance after start: 2 times
  - 10 sec before water start, water start, and 1 min best performance after start: 2 times
- Self-talk with EMG BFB for training in sea: 2 times × 1 min each.

Final part: Relaxation with BFB games (e.g. fish) for 10 min.

In the short third step "Simulation," which included three sessions, we used different video competitive situations such as 1 min before start, water start, turns, and direction changes. The imagery is practiced with "soft eyes" to enable the athlete to attend to the BFB information presented on the computer screen. The following is an example of protocol of a psychological training session in the Simulation step.

Place: Sport psychology laboratory
Day: Monday
Time: 13:00–13:50

Introductory part: Attention-focusing exercises: 2 time × 10–20 sec each
Main part:

- Muscle relaxation (30 sec) and imagery (30 sec before water start, water start, and 1-min best performance after start): 2–3 times. This exercise was accompanied with competitive fragments and noises, and EMG/GSR BFB
- Self-talk before water start: 2 times
- Decision making in various meteorological conditions:
  - Light-high wind, link between different wind directions and maximum drive: 4–5 situations.

Final part: Relaxation with BFB games: 10 min.

We focused on the relatively lengthy "Transformation" step which included 10 sessions. During this step the athlete mentally prepared for a specific upcoming competition. All material learned in lab was transformed into actual training setting. For example, on the boat we focused on quick relaxation-concentration exercise and in imagery we applied the skills during his performance actions specifically in the pumping and planning. We widely used this program during waiting periods, between races, and during recovery after training. After a few attempts by the athlete to apply our recommendations to his performance, the athlete said "You know, it's work! I understand and like it."

In Sdot-Yam we provided the athlete with two types of mental sessions in which we worked on during our sessions on the boat. First, short relaxation of 3–5 minutes with imagery in which the athlete image himself 30 seconds before the beginning of the race, actual water start and his best performance during the 1–2 minutes after the start of the race (see Figure 9.1).

Second, we gave special attention to the athlete's relaxation after the long and hard sea training. The main purpose of this intervention was recovery (see

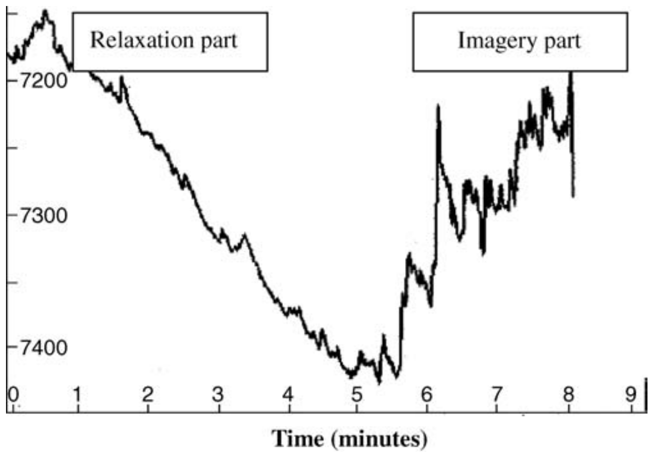

Figure 9.1 Relaxation and imagery during the "Transformation" step.

Figure 9.2). For example, during the weekend we worked on relaxation with EMG/GSR BFB which lasted 20–25 minutes and sometimes accompanied the exercise with music. Moreover, we reflected on all positive achievements in the current training program. Besides, the athlete worked at home on short relaxation which lasted 3–5 minutes, using portable GSR device.

During one of the first competitions in which the athlete, the coach, and Dr Blumenstein waited for the wind for about 1 hour in the boat in sea, the athlete "played" with the PC and portable BFB device in the boat, focusing on his concentration and relaxation skills with different BFB games.

For example, in these games the athletes use relaxation and concentration skills to move the surfer from left to right. According to our experience the athlete should achieve three jumps in a 1 minute period, while experiencing a state of optimal concentration (see Figure 9.3) or surf across the picture three times during a 1-minute period (see Figure 9.4). These games demonstrate to the athlete the link between his concentration-relaxation skills and his performance, helping the athlete

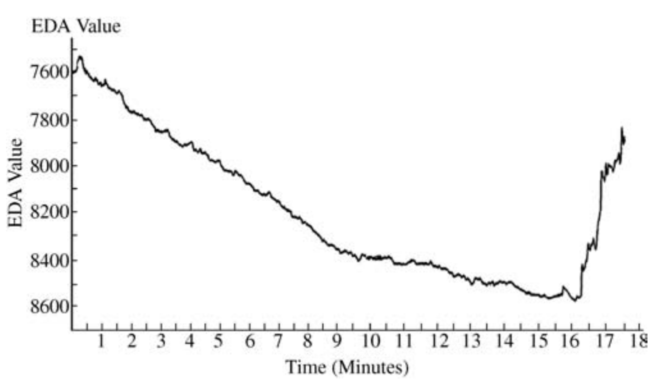

Figure 9.2 Relaxation during the "Transformation" step.

Figure 9.3 Jumping surf in the MD-Movies

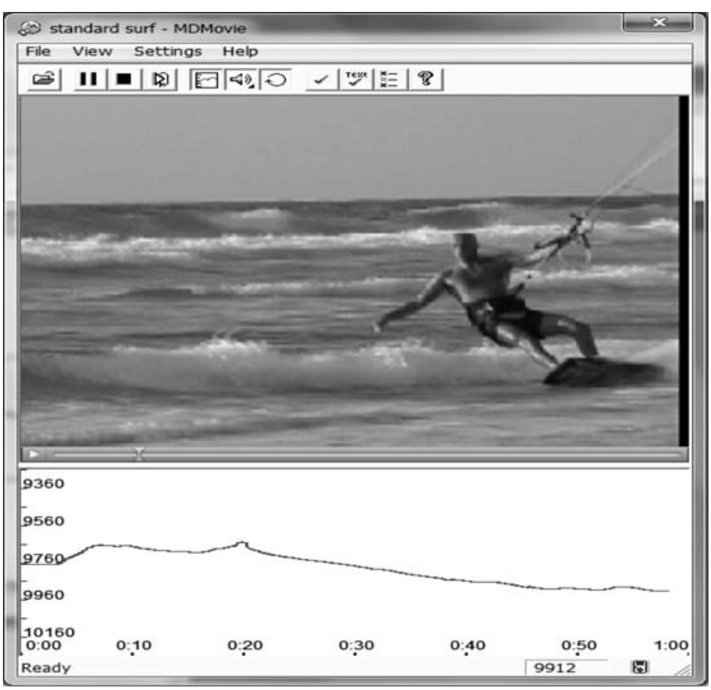

Figure 9.4 Surf in the MD-Movies.

to transfer this skill into practice, showing his current mental possibilities with psycho-physiological responses, and demonstrating his current self-regulation level.

After a few minutes other windsurfers from different countries approached us and asked for our permission to take part in the games. Most of them could not perform these exercises successfully according to our norms and realized that good performance requires training. This situation showed our athlete his strength and superiority in mental skills above his competitors. On that day he won in two races and said: "Today I was very fast and confident." This story is an indication of how the mere knowledge from the BFB devices has a positive impact on performance.

Besides performance benefits, the use of BFB training, helped to build good rapport and trust between the consultant, the athlete, and the coach. The major reason was that the BFB data was similar to the feedback the athlete received during his regular training. In addition, most of our mental training was provided in the sea together with the coach and the athlete. This situation had a positive effect on our relationship and there was a good atmosphere during our collaboration. An example of this positive effect can be illustrated in the following example. The night before an important international competition the coach called Dr Blumenstein and asked for his advice. The athlete could not fall asleep and refused to talk with the coach. Dr Blumenstein drove at midnight to the athlete's apartment and observed the situation. He took the athlete and the coach outside, walked for about 1.5 hours, and through humor and openness he succeeded in helping the athlete regain his regular emotional state. The next competition day was ordinary and the athlete achieved in two races fifth and seventh places. It was a good start to the day. The athlete achieved self-confidence and a mental calmness that helped him succeed in the following competitive days in which he was able to achieve a Bronze medal. That was possible due to the good relationship and confidence that the athlete, coach, and mental consultant shared.

To summarize this case study we would like to emphasize the importance of incorporating and implementing the mental training with the other practice preparation domains (i.e. physical, technical, tactical) as part of the overall training process (Blumenstein, Lidor, and Tenenbaum, 2007). Although the windsurfer was a known elite athlete before our relationship begun, our intervention optimized his competition behavior and his abilities to perform at his top level during the critical moment, the competition. The athlete improved his performance-enhancement skills, such as self-confidence, self-regulation, relaxation, and concentration. Another unique aspect to this case study is the fact that we conducted BFB training in the sea, beyond the lab sessions. In addition, there was a very good collaborative approach and relationship between the athlete, coach, and consultant, which to some degree can be related to the BFB training. An important conclusion to take from this case study is the flexibility that the consultant must have, being ready to provide psychological support and more specifically BFB training not only in laboratory setting but also in other unique conditions: land, sea, and maybe sky!?

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10

Case 8 – I Thought I Was Relaxed

The Use of SEMG Biofeedback for Training Awareness and Control[1]

Richard Harvey and Erik Peper

"I never realized that I braced my shoulders and held my breath while typing. Now I know the importance of not doing this and have tools to change." (Secretary in training program, San Francisco State University)

Introduction

Stiffness, tightness, pain or other muscle discomforts and exhaustion are common experiences for many people who work long hours at the computer or for athletes who push their body physically. Muscle discomfort often limits what they would like to do and, as symptom intensity increases, their discomfort tends to interfere with their work or athletic performances. Muscle discomfort is often described as soft-tissue injury. Many people assume that discomfort is the result of aging – you just have to accept it and live with it and you just need to be more careful while doing your job or engaging in sports (Sarkisian, Hays, and Mangione, 2002). More commonly, people experience neck, shoulder, back, leg, arm, and head pain of varying degrees while working at their job or enjoying their hobbies (Buettner *et al.*, 2008; Gerwin, 2001). Muscle pain, known as myofascial pain, is the primary cause for more than 30% of patients who visit their primary physicians with severe pain (Skootsky, Jaeger, and Oye, 1989). For adults the lifetime prevalence of neck pain is 66.7% (Côté, Cassidy, and Carroll, 1998); for adolescences the prevalence of

[1] Adapted with permission from: Peper, E., Booiman, A., Tallard, M., and Takebayashi, N. (2010). Surface electromyographic biofeedback to optimize performance in daily life: Improving physical fitness and health at the worksite *Japanese Journal of Biofeedback Research, 37*(1), 19-28; and, *Physical Therapy Products.* April 2007. http://www.ptproductsonline.com/issues/articles/2007-04_12.asp#10.

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back, neck and shoulder pain is increasing and in 2002 the prevalence rate for 18 years olds was 45% for girls and 19% for boys (Hakala *et al.*, 2002); while for employees working at the computer more than 30% experience neck and back pain, hand and arm pain, tingling and numbness, and exhaustion (Paoli and Merllié, 2001; Chauhan, 2003). The European Agency for Safety and Health at Work (2007) has reported that more than 25% of European workers complained of backache. The largest increase in back pain is seen among computing professionals and technicians. More than 25% of Europeans experience work-related neck–shoulder pain and 15% experience work-related arm pain (De Kraker and Blatter, 2005) while more than 90% of college students report some muscular discomfort at the end of the semester especially if they work on the computer (Peper and Harvey, 2008).

The common treatment strategies for muscle discomfort include heat, medications (e.g. nonsteroidal anti-inflammatory medication, muscle relaxants, or painkillers), massage and touch strategies such as Swedish massage, acupuncture, Shiatsu, aroma-therapy massage, Alexander technique, Feldenkrais, chiropractic, Rolfing, Somatics and therapeutic physical therapy manipulations and exercises (Cram, 2003; van Tulder *et al.*, 2003).

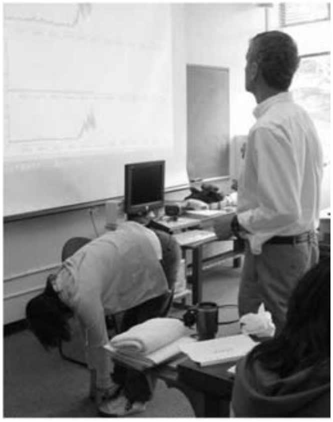
Although these therapeutic approaches are highly beneficial in reducing discomforts, the pain symptoms often return. The return of musculoskeletal pain symptoms suggests an ongoing dynamic muscle activation pattern, along with increased sympathetic arousal, that contributes to the development and maintenance of the chronic muscle discomfort. Muscle pain is aggravated by sympathetic arousal which in turn may lead to trigger-point activation that also increases the likelihood of referred pain (Gevirtz, 2006; Travell and Simons, 1983).

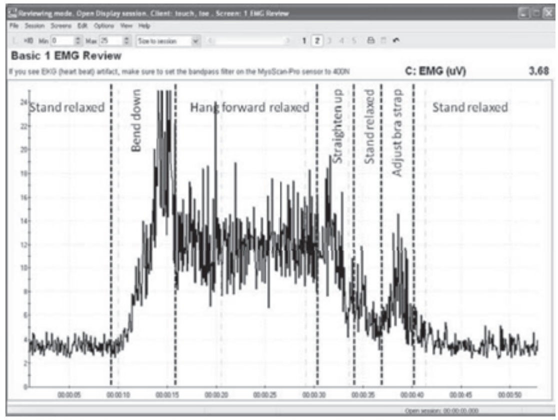
Lack of Muscle Tension Awareness

People are usually unaware of their muscle tension or autonomic arousal (Shumay and Peper, 1997; Stein, Schäfer, and Machelska, 2003). This lack of muscle awareness was recently demonstrated by Thorne *et al.* (2011) during a simple toe-touching task, in which about 95% of participants reported feeling relaxed while in fact the surface electromyographic (SEMG) recordings from their neck and back showed significant muscle tension.

While muscle tension was recorded from the neck using a band pass filter set at 100–200 Hz, participants were asked to: (a) bend forward as far as possible to touch their toes, while (b) hanging totally relaxed as possible, (c) returning gently to standing position; and (d) rate their subjective experience (as shown in Figure 10.1); 92% of the participants were unaware of their muscle tension as shown in Figure 10.1.

Following an initial rating of muscle tension, participants received SEMG feedback while bending forward and touching their toes until they could successfully relax their neck and back muscles while hanging down. The training was interactive and included auditory feedback, as well as tactile and verbal coaching. SEMG increases were indicated by an increase in auditory pitch and combined with verbal

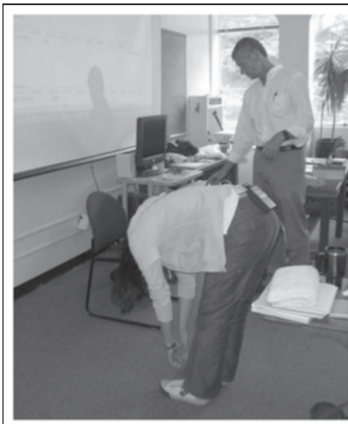


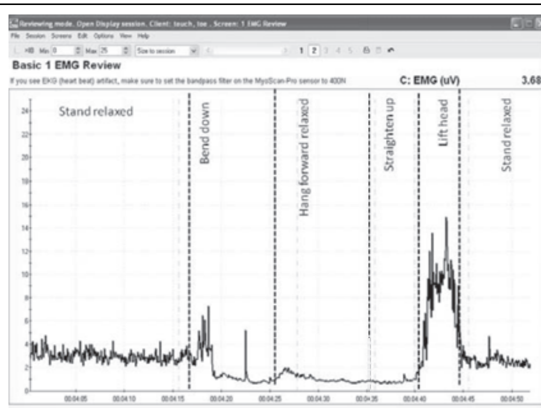


Note how head is lifted even though the person reports feeling totally relaxed	Pre-assessment of neck SEMG while performing a toe touch. Note the SEMG is increased even though the person reports being totally relaxed.

Figure 10.1 Initial assessment of Neck SEMG while performing a toe touch.

cues such as "Drop you head, let it hang." At other times, the practitioner would gently touch or move the head back and forth till the SEMG signal was low. The goal was to achieve success as defined by low SEMG activity while hanging relaxed. After the participants developed mastery of this skill (e.g. low SEMG muscle tension while hanging totally relaxed forward), the initial assessment was repeated without feedback. The results confirmed that mastery had been achieved without feedback as shown in Figure 10.2.





Note the head is hanging down.	Post assessment of neck SEMG while performing a toe touch. Note the SEMG is low and the person reports being relaxed

Figure 10.2 Toe touch after feedback training.

These findings suggest that simple and brief muscle awareness training is possible with teaching techniques that achieve the targeted goal (Mcphetridge *et al.*, 2011). In this study, all participants learned muscle tension awareness within a few minutes of training and were then able to hang down totally relaxed without any muscle tension. The SEMG feedback and the rapid success evoked an "Aha" experience such as

> "I feel much more relaxed and realize now how unaware I was of the tension I've been holding unnecessarily." (J.P.)
>
> "I'm more aware of my neck tension and body movement." (A.M.)

Clinically Relevant Findings

Clinically, a simple training protocol that illustrates recognizing and releasing covert muscle tension associated with toe touching creates hope. And, hope is a critical ingredient in motivating clients to continue to practice exercises to increase their health. It also generated an "Aha" experience which can be used for reframing illness and health beliefs. Furthermore, clinicians could adapt this protocol for making clients aware of a variety of dysfunctional muscle-tension patterns, and then train the client to develop mastery over their awareness of dysfunctional muscle-tension.

Psychophysiologically, the training protocol illustrates that during simple movements such as toe-touching, or work tasks such as typing, people are: (a) generally unaware of excessive increases in muscle tension during the task performance, (b) tighten auxiliary muscles that are not necessary for performing the task (inappropriate co-contractions), (c) do not fully relax task-activated muscles after the task has been completed, and/or (d) do not relax muscles even momentarily during task performance (e.g. lack of surface electromyograhic gaps/micro-breaks which prevents ongoing regeneration). These excessive and/or inappropriate efforts have been labeled as "dysponesis" by Whatmore and Kohli (1974).

Dysponesis

Dysponesis consists of misplaced and misdirected efforts (from the Greek: *dys* = bad; *pono*s = effort, work, or energy). Although dysponesis usually refers to the striated muscular system, the concept includes any nonfunctional efforts, unnecessary work, or activation of physiological system (e.g. cardiovascular, respiratory, endocrine, etc.) that are part of sympathetic arousal and vigilance. Unfortunately, dysponetic activity in both the musculoskeletal and autonomic nervous system is covert, and most people are unaware of unnecessary bracing or tightening, or increases in blood pressure, respiratory or endocrine function *while* they are engaged in various tasks.

An example of dysponesis can be observed by doing the experiential practice *threading a needle* described below.

Experiential practice: *Threading the needle* (Peper *et al.*, 2008)

Perform the task so that an observer would think it was real and not know that you are only simulating threading a needle.

Imagine that you are threading a needle – really imagine it by picturing it in your mind and acting it out. Hold the needle between your left thumb and index finger. Hold the thread between the thumb and index finger of your right hand. Bring the tip of the thread to your mouth and put it between your lips to moisten it and make it into a sharp point. Then attempt to thread the needle, which has a very small eye. The thread is almost as thick as the eye of the needle.

As you are concentrating on threading this imaginary needle, observed what happened? While acting out the imagery, did you raise or tighten your shoulders, stiffen your trunk, clench your teeth, hold your breath or stare at the thread and needle without blinking?

Most people are surprised that they have tightened their shoulders and braced their trunk while threading the needle. Awareness only occurred after their attention was directed to the covert muscle bracing patterns.

When performing the experiential practice of *threading the needle,* most people experience dysponetic and covert muscle bracing such as excessive neck, shoulder and trunk muscle tension that were unnecessary for the performance of the task. This bracing occurs when muscles are held tense for a long time period without episodic relaxation breaks (momentary rest periods). It tends to occur frequently as people use more and more small personal communication devices such as iPods, smart-phones, iPads, etc.

Optimum muscle functioning involves alternating between muscle activity and rest. The lack of episodic muscle relaxation to a resting baseline after use is an indicator of dysfunction that can be assessed with the Sella's muscle tension protocols (Sella, 1995, 2003). In Sella's (1995, 2003) protocols the person is asked to tighten a muscle for 9 seconds then relax it for 9 seconds, and repeat this five times. If the muscle tension does not return to a resting baseline level, it indicates that the muscle may not regenerate which suggests an etiology for myalgia.

The treatment of this myalgia would include teaching the person to relax the muscle before again tensing the muscle. The diagnostic power of Sella's (1995, 2003) assessment is illustrated in the example of a 45-year-old female somatic therapist, who was trained in body movement and awareness and volunteered to be assessed. She was asked to raise her shoulders minimally until she became aware of the tension. However, during this task, she was unaware of the co-contraction of her right forearm extensors and the lack of return to the relaxed baseline in the upper right trapezius muscle as shown in Figure 10.3. When inspecting the data, the therapist hypothesized that this could be associated with stiffness and pain in her

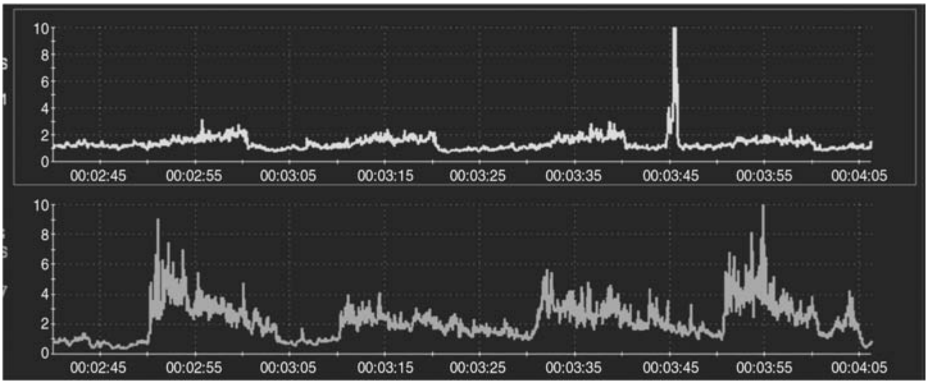


Figure 10.3 Example of dysponesis illustrated by the co-contraction of the right forearm extensors and the trapezius muscle (r-upper trap) not relaxing after lifting the shoulder until she felt the minimal sensation of tension. After each minimum contraction the right upper trapezius muscle did not return to baseline as illustrated by comparing the first to the fourth relax condition (with permission from Peper *et al.*, 2010).

shoulders. She was totally surprised that the therapist had identified her actual symptoms. The SEMG had made the invisible visible.

Making the Invisible Visible

In clinical and educational practice, SEMG biofeedback is a superb tool for demonstrating lack of muscle awareness as well as teaching control over muscle function and enhancing the client's sense of control and mastery. In particular, SEMG feedback protocols facilitate making unseen muscle tension visible, unfelt muscle tension felt. The treatment strategy in muscle awareness protocols includes teaching the trainee to relax their muscles before using the muscles again. In addition the training focuses on transfer the learning into daily life patterns. To achieve this mastery in real life practice may vary from one to 20 sessions (Peper, Harvey, and Tylova, 2006; Peper *et al.*, 2008; Sella, 1995; Sella, 2003). The clinical applications of this approach are illustrated in the following examples of (a) improving health at the computer and (b) enhancing performance on an elliptical exercise machine.

Example 1: Improving Health at the Computer

Lack of muscle tension awareness is a common characteristic underlying many musculoskeletal disorders, where the person only becomes aware after it hurts (Peper, Harvey, and Tylova, 2006). A major cause of discomfort is the holding of chronic and unnecessary muscle tension which may lead to illness if unaddressed (Peper, Harvey, and Tylova, 2006). For example, Peper, Harvey, and Tylova, 2006) demonstrated that 95% of employees, before receiving SEMG biofeedback training, automatically raised their shoulders as well as maintained low-level tension in their forearms while keyboarding and/or using a computer mouse (mousing), as well as increased their breathing rates and decreased eye-blinking rates.

The structured assessment protocol as described in details by Peper, Harvey, and Tylova (2006) and Shumay and Peper (1997) is a powerful tool to identify common forms of muscuskeletal dysponesis while working on the computer. For example, almost every person while performing data entry tightens their shoulders and covertly holds that tension without interrupting it with episodic relaxation micro breaks. The protocol consists of assessment, discussion of the assessment and training with physiological signals monitored from the trapezius, deltoid, and scalene SEMG and abdominal and thoracic respiration.

Assessment

The client sits in front of the computer and is asked to relax with their hands on his lap for 1 minute, rest their hands on the keyboard and mouse while relaxed for 1 minute, perform data entry such as typing for 2 minutes, rest with hands on the keyboard and mouse for 1 minute, perform a mousing task for 2 minutes and then rest their hands on their lap for 1 minute. After the assessment, they are asked what they experienced. Almost all report some tension in their forearm as they typed or used the mouse. At the same time almost all were unaware of the increased tension in their shoulders as well as shallower breathing as illustrated in Figure 10.4.

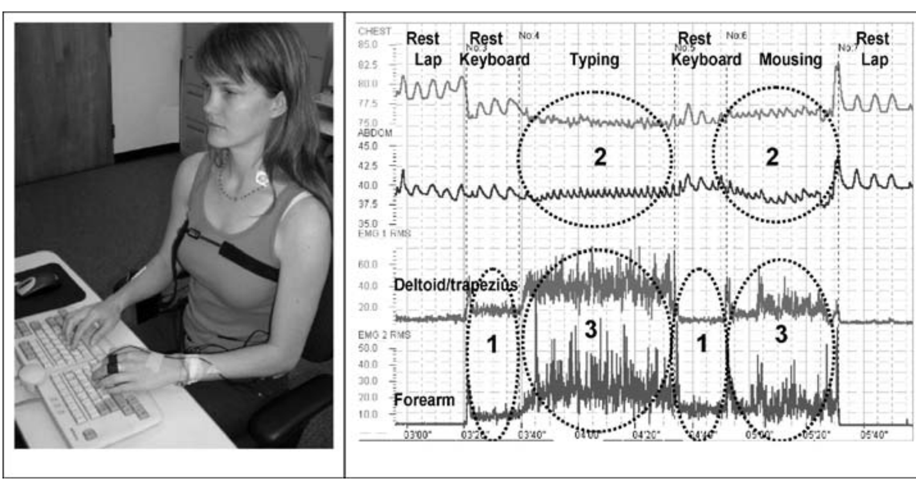


Figure 10.4 A representative recording of a person working at the computer. Note how (a) the forearm and shoulder (deltoid/trapezius) muscle tension increased as the person rests her hands on the keyboard without typing; (b) respiration rate increased during typing and mousing; (c) shoulder muscle tension increased during typing and mousing; and (d) there were no rest periods in the shoulder muscles as long as the fingers are either resting, typing, or mousing.

The clinical intervention consists of discussing the physiological assessment recordings, training the person to reduce shoulder tension and/or take episodic micro breaks to relax the static muscle tension to 1 uV (the absence of any muscle contractions) and breathe slower while working.

Discussion of the Assessment

The discussion of this short assessment is used to change the beliefs of the subject and describe the rationale of the training protocol. The discussion provides an opportunity for an "aha" moment as the person becomes aware of the covert tension and/or shallow breathing. The discussion is also an opportunity for teaching the person about muscle fatigue mechanisms. For example, Lin *et al.* (2002) stated that "Muscles rich in type II fibers are more susceptible to fatigue in part because their glycolytic metabolism causes acidification of the muscle bed under repeated use," suggesting a mechanism for why some muscles fatigue quickly if regenerative micro breaks do not occur.

Another technique for illustrating the need for muscle regeneration and micro-breaks is the simple experiential exercise called *lifting your leg*. In this exercise the person is asked to just lift their foot up from the ground as if they are taking a step and freeze in this location. When the person is asked to hold up their leg in a static position, they can only do it for about a minute or so before awareness of fatigue sets in. In contrast, if they were walking, fatigue would take a long time because the leg muscles continuously alternate, relaxing after every short contraction so that there is a continuous flow of nutrients and removal of the metabolic waste products as shown in Figure 10.5. Similarly when people are captured by the computer and without interruptions, they tend to hold static neck and shoulder tension and only become aware of the tension when they begin to feel discomfort such as pain or burning sensation.

Training

The training process consists of SEMG training recorded from the forearm and the trapezius, deltoid and/or scalene muscles. The components consist of awareness training, recognizing tension in the neck and shoulders, as well as being able to drop the arms to the lap until the SEMG is at minimal levels. A final step finally includes being able to perform these tasks correctly without feedback. For an extended description of muscle awareness training procedures designed for reducing dysponesis, see Peper and Gibney (2006) and Peper *et al.* (2008) Unit 1, Exploring Dysponesis. The number of treatment sessions varied depending on the muscle-tension awareness skills to be mastered. The challenge for the person is to remember to take the micro-breaks, relax the shoulders and maintain slower

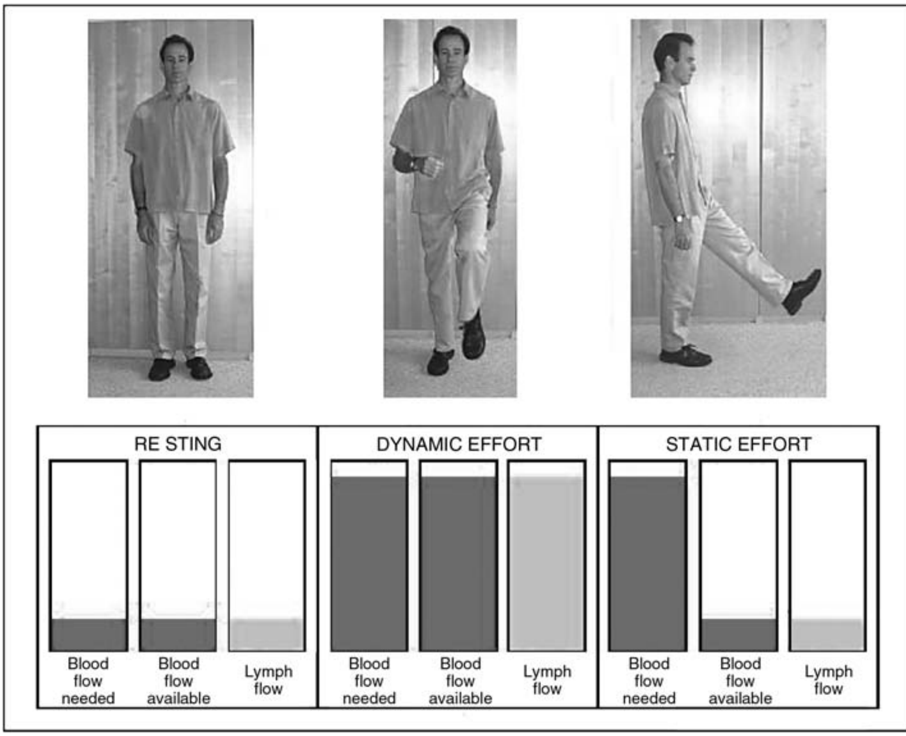


Figure 10.5 Graphic illustration of how blood flow and lymph circulation is reduced during static efforts.

breathing while working. When clients practice at work, they overwhelmingly report less neck and shoulder pain and more energy at the end of the day. As one participant said after integrating many micro-breaks at work, "There is life after five." This implied he had much more energy at the end of the day than before (Peper, Gibney, and Wilson, 2004).

Example 2: Enhancing Performance Working out in the Gym on an Elliptical Machine

I would much rather put my effort into productive exercise as opposed to exerting unnecessary energy which did nothing more than to hinder my abilities and efforts to work at my fullest potential. This awareness will be beneficial in improving my posture while working out, reducing my stress and fatigue and hopefully making the workout more enjoyable with less strain on my body. (Marie Tallard)

A healthy 51-year-old woman attending a biofeedback training program was assigned homework to indentify misdirected efforts and to reduce it. While doing her homework, she observed minor episodes of dysponesis but did not think that it significantly impacted her daily life in any way. However, the next morning when she did her usual workout on the elliptical machine in the hotel fitness room, she suddenly noticed that her shoulders were extremely tense and that she was gripping the handle bars of the equipment with all of her might.

Discovery of Dysponesis

She was amazed by the discovery of increased muscle tension in her shoulders as well as her hands because she had never realized that she needlessly tightened her shoulders, arms, and hands while using equipment that only required using the arms for balance purposes. In fact, she reported that bracing her shoulders, arms, and hands on the elliptical machine felt very familiar.

Observing and reflecting about her dysponesis as a homework exercise, she became aware of associated thought and emotional patterns. She realized that this problem originated several years ago when she fell from a treadmill while running. Since that time, she has been slightly afraid of falling and more cautious while using any equipment at the gym. Although she pushes herself to exercise daily because of the health benefits, daily exercise is an ongoing struggle as she despises the aches and pains associated with working out. She realized that these negative thought patterns may also have contributed to the physical stress that she feels when exercising. After becoming aware of her tight shoulder, arm, and hand muscles while gripping the bar, she tried to relax her muscle more often. She then struggled with a continual loss of attention and awareness of the tension. The moment her attention and awareness drifted, she would fall back to her dysfunctional pattern of gripping the handlebars with every ounce of strength.

Biofeedback Training to Correct Equipment-related Dysponesis

The next morning during an actual workout on the elliptical machine she self-monitored her shoulder and arm tension with SEMG using a portable SEMG biofeedback device (Myotrac produced by Thought Technology Ltd) with the bandpass filter set from 100 to 200 Hz. The basic feedback training is shown in Figure 10.6.

She initially placed the triode electrodes first on the right and then the left mid to upper trapezius muscles. The auditory signal provided immediate feedback of her shoulder muscle contractions. Any auditory signal meant that dysponesis was occurring. With the auditory feedback, she immediately reduced the tension in her shoulders. She quickly realized that, although the problem was rectified in the

Figure 10.6 Working out on the elliptical machine. Left figure shows the normal tense pattern with her shoulders raised and hands gripping the bars; right figure shows the relaxed pattern. The position of her elbow/arms is relevant in reducing the muscle tension. SEMG was recorded from the right and left upper trapezius and forearm flexors muscles (with permission from Peper *et al.*, 2010).

shoulders, it was still present in her arms. She then moved the electrodes to her arms and was able to reduce the muscle tension in the arms.[2]

Her mastery in controlling the SEMG activity of her upper trapezius and forearm extensors was monitored without giving her feedback. The SEMG triode electrodes were placed on the right and left upper trapezius and right and left forearm flexor and amplified with Myoscan Pro sensors (bandpass filter 100–200 Hz) and recorded with Thought Technology Ltd, Procomp Infinity system using version 4.1 software. She was instructed to work out on the elliptical machine in her normal/tense and newly learned relaxed pattern. A comparison of her "tense" workout to her "relaxed" workout at the same workload intensity revealed: (a) that her SEMG from her left and right upper trapezius and left and right forearm muscles showed high muscle activation as compared to the relaxed workout and, (b) her right side showed more muscle activity than her left side, as shown in Figure 10.7.

[2] In this case, the shoulders can be relaxed because the hands are holding the side bars of the elliptical machine. We generally do not recommend this type of elliptical machine because it limits the natural cross-crawl movement patterns and often causes the person to tense their shoulders and back. An improved elliptical machine that mimics the normal walking movement patterns encourages the person to move their arms as well as their legs. In that case, the upper trazezius muscles would be activated as the arm goes forward and relax when the arm comes back. This cross movement crawl pattern enhances hip, spine and shoulder coordination.

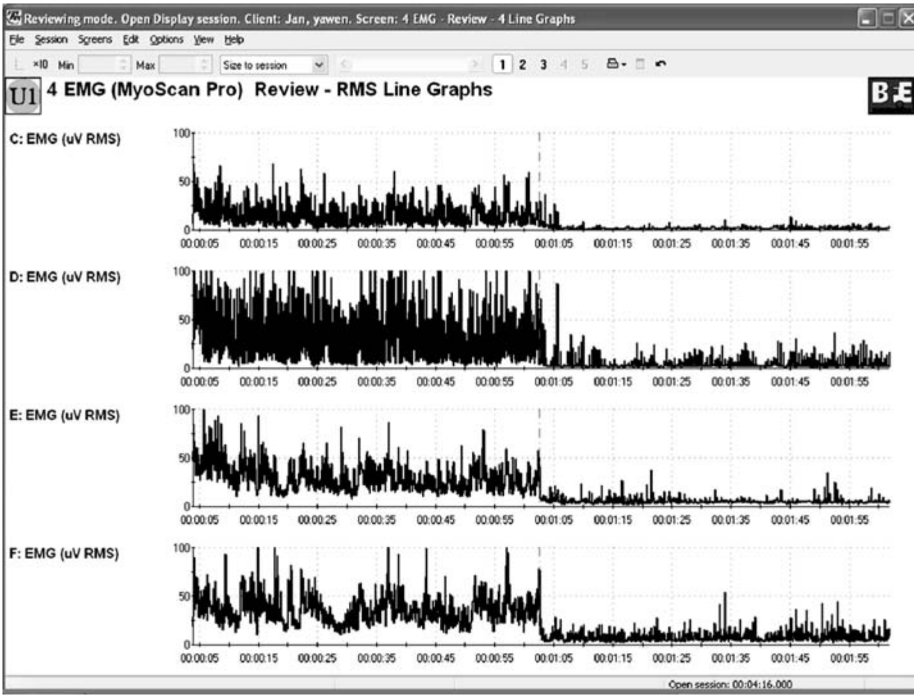


Figure 10.7 SEMG during Normal/Tense versus Relax workouts on the elliptical machine. During her habitual workout the left and right upper trapezius as well as the left and right forearm flexors are continuously activated while during the relaxed workout, the SEMG is much less active and returns continuously to baseline. In both conditions the right side shows more SEMG activity than her left side (with permission from Peper *et al.*, 2010).

The SEMG data also showed that during the "tense" versus "relaxed" workout, the SEMG did not return to baseline. The lack of return-to-baseline can be seen more easily when the SEMG μV amplification range is changed from 0–100 μV in Figure 10.7 to 1–10 μV in as shown in Figure 10.8.

Performance Benefits of Reducing Shoulder and Arm Dysponesis

By reducing the dysponesis in her shoulders and arms, she noticed that much less effort was required to complete the same workout and she decided to step it up to the next more challenging workout level. She was able to complete the workout program at a higher level and noticed less fatigue upon finishing. The following day she worked out without the biofeedback equipment and continued to be aware of any dysponesis. As the workout progressed, dysponesis was minimal and she progressively stepped-up her workout to the next level whenever possible. She was extremely encouraged by this discovery and with her efforts to "fix" the problem. She realized that she would much rather put her effort into productive exercise as

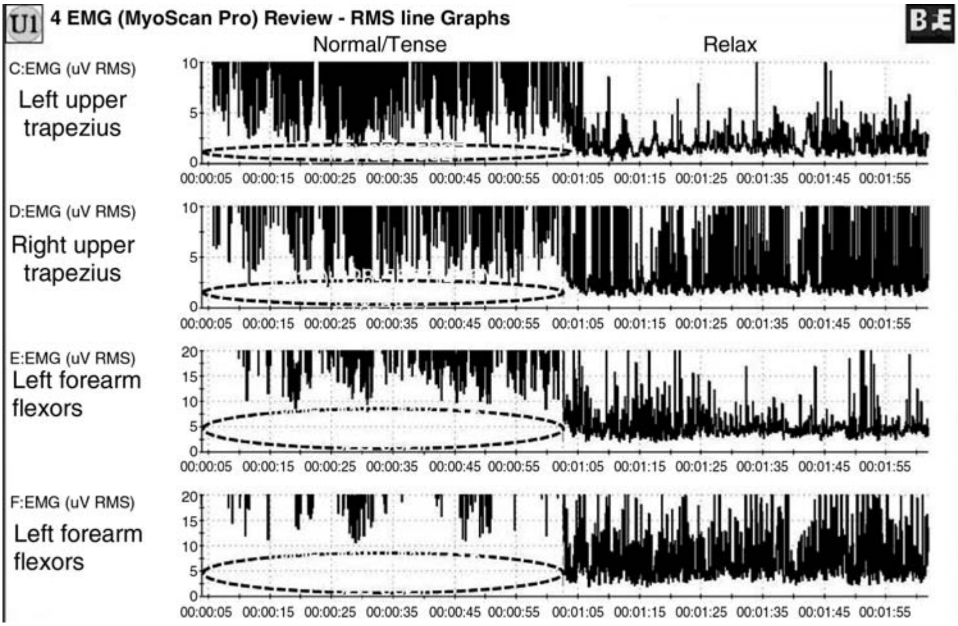


Figure 10.8 SEMG set between 0 and 10 μV to show the SEMG activity. During the Normal/Tense habitual workout, the SEMG shows no SEMG gasp or momentary rest periods, while during the relax workout the SEMG continuously returned to baseline which indicated that the muscles momentarily relaxed (with permission from Peper *et al.*, 2010).

opposed to exerting unnecessary energy which hindered her abilities and efforts to work at her fullest potential.

This awareness of dysponesis and the ability to drop her shoulders were beneficial in improving her posture while working out, reducing stress and fatigue and making the workout more enjoyable with less strain on her body. She reported after the training: "I am 51 years old and am not willing to accept that I am not capable of making physical improvements. My task will now be to maintain this awareness in order to break this bad habit 100% of the time and to transfer this discovery to other areas of my workout as well as to my daily life. When this goal is achieved and new habits are permanently formed I believe the benefits will be obvious in my everyday life and not just in the gym."

At a six-month follow-up, she continues to observe her dysponesis during workouts and daily activities. At her home gym, she was able to keep her shoulder and forearm muscles relaxed while performing the elliptical workout and she reports making steady and significant progress. She has been able to increase the difficulty of her workout to include numerous periods of high intensity movement and extend her workout by 15 minutes daily without feeling tired. More importantly, she has generalized the concept of dysponesis awareness and reduction into other areas of her life. For example, she became aware that gripping the steering wheel made her feel much more stressed while driving and when she relaxed her shoulders and arms, she felt much calmer and able to handle the difficult driving situations. In addition, she has become much aware of poor posture and muscle tension while writing, working at the computer, working with clients, cooking, sewing, reading, sleeping, and even relaxing. Her awareness of these situations has helped her to take control and make the necessary changes to reduce the physical stress that she encounters every day. This in turn has helped to alleviate mental stress and fatigue.

Discussion

The teaching examples presented in this chapter illustrate the efficacy of the evidence-based SEMG biofeedback approach in the assessment and reduction of dysponesis. The success of using an experiential teaching approach is based upon the following components:

- Biofeedback training presumes an integration of mind and body; that thoughts such as memories, and emotions affect the physiology and vice versa. This is based upon the psychophysiological principle stated by Green, Green and Walters (1970) that "Every change in the physiological state is accompanied by an appropriate change in the mental emotional state, conscious or unconscious, and conversely, every change in the mental emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state."
- Identification and reduction of dysponesis during simulated or actual task performance (e.g. toe-touching or, working out on the elliptical machine) is useful in training. The training focuses upon changing the use of a person's body so that the dysfunctional patterns are changed and eliminated when the person performs their tasks after leaning new, healthy muscle use patterns.
- Immediate feedback allows clients to experience success and hope which provides motivation for continued practice and for further improvement.
- Mastered skills learned in the office need to be transferred and generalized into daily life and while performing other tasks. Thus, the awareness of dysponesis followed by the reduction of dysponesis needs to be practiced in the daily activities at home, at work, and while performing sports and hobbies. This can be enhanced through teaching clients how to monitor their behavior and changes and record these observations on logs. People need to change their behavior in real life and not just during the office training session.

In summary, dysponesis contributes to the development and maintenance of illness. Learning to be aware of and reduce dysponesis may significantly help in reducing illness and improving health. SEMG monitoring and feedback makes the unaware muscle dysponesis aware and visible. With SEMG feedback, clients can learn voluntary control to inhibit dysponesis. Biofeedback protocols assist in developing the internal somatic/sensory awareness necessary for improving health. We recommend that children and adults are taught dysponesis awareness and inhibition to prevent illness onset since, prevention is much easier and much more cost effective than treatment.

> I am amazed how many areas of my life need improvements. My awareness has been most helpful in changing my actions. (Marie Tallard)

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11

Case 9 – Psychophysiological Assessment and Biofeedback during Official Baseball Games

Procedures, Methodologies, Findings and Critical Issues in Applied Sport Psychology

Roland A. Carlstedt

Introduction

This chapter presents a validated multifaceted assessment and intervention protocol (Carlstedt Protocol; CP, 2004, 2007a, 2007b, 2009a, 2009b) that has been used on hundreds of athletes over the last 15 years. It is conceptually based on an integrative individual-differences model of peak performance that is supported by strong construct validity and an extensive evolving database of psychophysiological and performance relationships and findings across numerous sports. The CP stresses ecological validity, real-time psychophysiological monitoring, biofeedback-based multimodal intervention and importantly, extensive efficacy testing. The protocol involves a step-by-step hierarchical evidence-based approach that is predicated on the comprehensive assessment of athlete mind-body-motor response tendencies in pre-intervention and intervention phases prior to, during and after practice and *official competition* (real games/matches). The goal of the protocol is to establish statistical relationships between interventions and objective macro and micro outcome measures of a specific sport, the benchmark for determining whether a mental training method works and to what extent. It was designed to bring accountability to the assessment and intervention process in the fields of sport psychology and biofeedback.

Readers will be exposed to specific components of the CP that were applied to starting players on an elite youth baseball team. Group data and findings will be presented along with contrasting case studies that demonstrate wide variability in terms of outcome or intervention efficacy. Procedural and methodological issues and

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considerations that are crucial to higher evidentiary athlete assessment and mental training will be featured. It should be noted that this is the first study on record in which athletes' psychophysiological responses were monitored and measured *during official league games* over the course of an entire season. Pre-intervention assessment and intervention phases (biofeedback) were carried out prior to every at-bat (over 1200 data points/repeated measures; about 100–150 at-bats per player). Complete datasets of psychometric, behavioral, psychophysiological (heart rate variability; HRV) and critical moment (CM) performance statistics (predictor and macro-micro criterion measures) were generated for analysis and athlete (client) feedback purposes.

In addition to discussing group and case study findings, particular attention will be paid to critical issues in applied sport psychology/sport psychophysiology and biofeedback. A goal of this chapter is not only to present data and findings on athletes who have experienced the CP but also advocate for the integration of procedures and methodologies that are vital to evidence-based applied sport psychology, the credibility of the field of sport psychology/biofeedback and its practitioners. Consequently, points of critique and rationale for doing specific things within the protocol will be discussed throughout the chapter. As I progress through specific procedures of the CP player data will be inserted along with comments regarding their relevance. Certain procedures, methods and response outtakes (e.g. heart rate variability reports) will also be shown and discussed.

A Hierarchical Evidence-based Step-by-Step Ecological Protocol

Assessment of primary higher order psychological factors: The "Athlete's Profile"

The first step of the CP involves establishing an athlete's "Athlete's Profile" which is derived from the Carlstedt Subliminal Attention-Reactivity-Coping Scale-Athlete version (CSARCS-A). This test measures validated approximations of hypnotic susceptibility/subliminal attention (HS/SA) neuroticism/subliminal reactivity (N/SR) and repressive coping/subliminal coping (RC/SC) as attested to by its moderate to high convergent validity coefficients with the Tellegen Absorption Scale (TAS), Stanford Scale of Hypnotic Susceptibility (SSHS), NEO-Neuroticism sub scale, Eysenck Personality Inventory and Marlowe-Crowne Scale; ($r = 0.85$–0.90; see Carlstedt, 2004 for a complete overview of these tests). The CSARCS-A has also exhibited high predictive validity across numerous replication and extension investigations (up to adj. r^2 0.70; Carlstedt, 2004)[1].

[1] The CSARCS-A test battery can be accessed via the American Board of Sport Psychology test center (email rcarlstedt@americanboardofsportpsychology.org; Key Word: CSARCS-A for access instructions, test codes and passwords; the CSARCS-A and clinical analogue tests can also be accessed through the same email address).

Key personality and behavioral constructs in the performance equation

Hypnotic susceptibility/subliminal attention, neuroticism/subliminal reactivity and repressive/subliminal coping are considered traits and behaviors that have distinct mind-body correlates and dynamics. Research has localized them in specific brain regions and functionally with specific patterns of EEG, heart rate variability and muscle tension (Carlstedt, 2004; Davidson, 1984; Wickramasekera, 1988; Davidson, Schwartz, and Rothman, 1976; Tomarken and Davidson, 1994). These measures are emerging as *Primary Higher Order* (PHO) factors in mediating performance, especially during critical moments of competition when the perception of threat and competitive stress are thought to be the greatest, instances when certain athletes are expected to be most vulnerable to negative intrusive thoughts. When interacting together, these measures have been shown empirically to supersede all other psychological variables in affecting and predicting psychological performance in athletes, especially during critical moments of competition (Carlstedt, 2001a, 2004, 2007a, 2007b). These isolated PHO measures have been found to be intimately linked to key components of peak performance, including attention (focus), intensity (physiological reactivity), cognitive processing/strategic planning, motor readiness and emotional control. A recent longitudinal study of tennis (spanning five years) and baseball players (season-long; presented herein) has found these traits and behaviors to be strongly associated with objective performance outcome measures as well as neurocognitive responses that have well established functional and anatomical cortical concomitants. In addition, they have been found to influence pre-and post-competition heart rate variability responses. In one form or another (interacting or singularly) HS/SA-N/SR-RC/SC have accounted for up to 70% of the variance in specific neurocognitive and HRV criterion measures and up to 40% of the variance in the performance equation that

	Outcome	N	N	N	N	N	N & HRV	N & HRV	HRV	HRV
HS/SA	0.36	–0.68 N13	–0.58- N21	–0.68- N25	0.58- N21	0.52- N22	–0.55 N36	–0.57 N44	0.28 HR-sdnn/pre	0.31 L/H-post
N/SR	0.48	0.52- N12	–0.52- N14	0.79- N17	–0.40- N30	–0.62- N34	–0.31 HR-pre	0.41 VL-pre	–0.24 Hr-post	-0.35 HR-pre
RC/SC	-0.41	–0.72- N12	0.89- N14	–0.54- N17	0.73- N30	0.53- N30	0.43 HR-pre	0.35 L/H-pre	0.37 LF-post	0.29 Power-post

Note: HS/SA = hypnotic susceptibility/subliminal attention; N/SR = neuroticism/subliminal reactivity; RC/SC = repressive coping/subliminal coping; Outcome Measures: statistical performance measure (games lost); N12-pre-frontal/parietal/occipital; N13-pre-frontal/frontal/parietal/temporal/basal ganglia/ thalamus; N14-same as 13; N17-frontal; N21-pre-frontal/parietal/occipital/anterior cingulate; N22-same as 21; N25-same as 21; N30-pre-frontal/frontal/motor/parietal/occipital; N34-pre-frontal/frontal; N36-same as 34; N44-same as 34 and anterior cingulate. HRV Measures: HR=heart rate; VL = very low frequency; LF = low frequency; L/H = low/high frequency ratio. NOTE: N measures are associated with implicated brain regions.

Figure 11.1 Sample outtake of correlations between primary higher order factors and performance outcome, neurocognition and heart rate variability.

can be attributed to psychological factors (personality traits, behaviors, and psychophysiological responding (Carlstedt, 2001a, 2004, 2007a, 2007b).

The statistics in Figure 11.1 are but a handful of a plethora of revealing findings that strongly support the contention that HS/SA-N/SR-RC/SC are the most potent psychological mediators of performance under pressure. I recommend that all athletes should be assessed on these measures prior to starting a biofeedback or any other intervention regime. In addition to guiding biofeedback, the established "Athlete's Profile" is a strong predictor of intervention amenability and compliance tendencies, pain thresholds, attentional control during competitive stress, coachability and the placebo-nocebo effects (Wickramasekera, 1988; Carlstedt, 2004, 2009a, 2009b).

Primary Higher Order Factors and Their Relevance to Biofeedback

Hypnotic susceptibility (Subliminal Attention; HS/SA)

Hypnotic susceptibility can be considered the "Zone" trait in that peak performance experiences (e.g. "zone" or "flow") have been described in similar terms as certain components of the hypnotic response (Carlstedt, 2004). It is marked by intense but effortless focus. It should be emphasized that hypnotic susceptibility is an omnipresent mode of information processing independent of actually being hypnotized. In other words, one does not have to be formally inducted to experience a hypnotic response or state. HS/SA is a cognitive style that can occur unconsciously and lead to intense periods of attention. Knowing an athlete's level of HS/SA is important to predicting intervention amenability and compliance. Athlete's who are high in this measure are more amenable to visually-based interventions like mental imagery and hypnosis. Consequently, biofeedback, should been structured to contain strong visual components or feedback when used with athletes who are in the high range for HS/SA to foster better compliance (Carlstedt, 2004; Fromm and Nash, 1992).

Neuroticism (Subliminal Reactivity; N/SR)

Neuroticism can be viewed as the "Zone buster." This trait is associated with excessive negative and catastrophic thinking and hyperintensity (excessive physiological reactivity) especially when a person is under stress. Individuals who are high in N/SR also tend to have elevated physiological reactivity even at baseline and in the absence of apparent stress and when taking standardized stress tests (e.g. Serial 7s). While heightened reactivity at baseline may facilitate activation levels that are necessary for competition, athletes who are high in this measure have also been shown to be more vulnerable to negative intrusive thoughts that can disrupt motor performance (Carlstedt, 2004). Athletes who exhibit high levels of this trait are amenable to and can benefit from biofeedback but tend to need intensive and extensive training to overwrite faulty or dysfunctional psychophysiological response tendencies that may have taken a lifetime to develop. Of athletes who participated in various HRV biofeedback intervention studies in the context of my work with teams and private clients, those who scored high to very high in neuroticism/subliminal reactivity had the most difficulty generating high scores on the Stress Eraser device and also took the longest to achieve shifts from very low (excessive sympathetic nervous system (SNS) reactivity at baseline) to high frequency HRV (relaxation response). They also had the highest levels of change in physiological reactivity between the baseline and mental challenge conditions of the Serial 7s stress test (greater shifts toward sympathetic nervous system predominance (SNS) Carlstedt, 2004, 2007a, 2007b).

Repressive coping (Subliminal Coping; RC/SC)

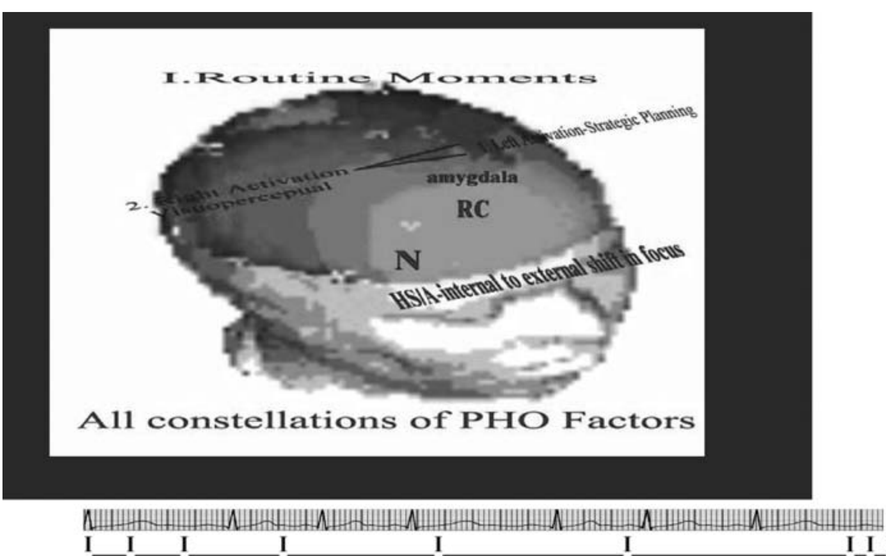
Repressive coping can be considered the "great facilitator" of zone states in that it functions to block the negative effects of high neuroticism/subliminal reactivity, thereby facilitating focus on the task at hand (e.g. needing to get a big serve in, or sinking a crucial putt when it counts the most). Individuals who score high for RC/SC have been shown to functionally inhibit the interhemipsheric transfer of negative affect (N/SR) from the right to the left frontal brain hemispheres (Tomarken and Davidson, 1994). Athletes who are high in this behavior seem impervious to (or don't even generate) negative intrusive thoughts and are more likely to successfully master critical moments during competition than athletes who are low in RC/SC. Athletes who are high in RC/SC also tend to have high self-esteem and confidence. Nevertheless, despite its performance facilitative properties, athletes who are high in RC/SC can be difficult to coach. They often are so convinced of their ability and (self-perceived) superiority that they may fail to recognize technical and physical deficiencies and not listen to constructive criticism to remediate them. They tend as well to be skeptical and noncompliant when it comes to participating in interventions. Overall, though, "mentally tough" athletes score high in RC/SC (Carlstedt, 2004). Nevertheless, even mentally tough athletes falter at times and can benefit from mental training techniques to enhance attention or motor performance. Consequently, when working with athletes who are high in RC/SC (who can be resistant, skeptical and noncompliant) one must convince them of the potential benefits of a mental training method. This can be achieved by providing them with evidence that an intervention works and show them how it affects mind-body-motor responses to enhance performance. Biofeedback is an excellent procedure for convincing the unbelieving, skeptical athlete that the mind, indeed, can influence the body and motor control since self-generated response tendencies are readily apparent on a screen or in the form of audio feedback (Carlstedt, 2001b, 2004). The high RC/SC athlete may actually view the biofeedback process as some sort of internal or personal competition that they want to succeed at (e.g. readily demonstrate a prescribed biofeedback response).

Construct Validity of the Carlstedt Protocol Athlete's Profile and Critical Moments Model of Peak Performance

Independently, the aforementioned PHO measures all have potential performance facilitating or disrupting effects. While they usually are relatively dormant during routine phases of competition, when critical moments are encountered these measures have been shown to *interact* to exert a potent influence (positive or negative) on psychological performance as a function of their specific constellation (combination). Here is how they are hypothesized to work together to influence performance.

The mind–body dynamics (heart rate deceleration (HRD) and cortical shifts) that are depicted in the Figure 11.2 have been well documented in numerous studies of athletes performing during routine phases of competition (irrespective of an Athlete's PHO profile) whereby spectral analyses of total power (brain frequencies and their amplitudes) have revealed differential levels of activation between brain hemispheres as a function of internal or external focus or task orientation (e.g. strategic planning vs. visuo-perceptual attending). An observed seamless relative left to right brain hemispheric shift just prior to the commencement of action has been associated with faster reaction times, motor/technical control and better outcome (Carlstedt, 2001a, 2004 for a review of EEG studies on athletes; Landers *et al*., 1994).

By contrast, in negatively predisposed players (high HS/SA, high N/SR, low RC/SC), whenever critical moments occur or when stress increases (whether real or self-perceived), this seamless left to right brain hemispheric shift that usually takes place during routine moments in all athletes (athlete populations and species-wide



Note: Heart rate deceleration occurs prior to action during routine moments regardless of an "Athletes Profile."

Figure 11.2 Cortical dynamics and heart rate variability during a routine pre-action phase.

response in anticipation of an impending response) is disrupted. A cascade of emotional responses that is hypothesized to originate in the amygdala (the brain's repository for emotional, fear and failure memory); is thought to set off a "fight or flight" response (excessive (SNS) physiological activation) that is mediated by negative, catastrophic and chaotic thinking. Negative affect (right frontal region-based neuronal ensembles) that normally remain dormant during routine moments of competition become active and infiltrate the left frontal region of the brain. This occurrence is thought to disrupt an athlete's strategic planning phase and the subsequent shift to more right frontal hemispheric and motor cortex brain activity that is associated with focusing and visuo-perceptual demands of a particular impending technical action (priming of task-specific motor pathways).

These negative intrusive thoughts (e.g. "I hope I don't lose this point") take over, leading an athlete to fixate on negative emotions and images instead of preparing for action. As a result, one no longer observes the above described relative left-to-right shift in brain activity. Instead sustained increased activation (varying levels of beta EEG activity) in the left frontal hemisphere has been found to occur. Essentially, athletes who are burdened with high neuroticism/subliminal reactivity and low repressive coping/subliminal coping remain "stuck" in the ruminative left-brain hemisphere and are often rendered incapable of exhibiting

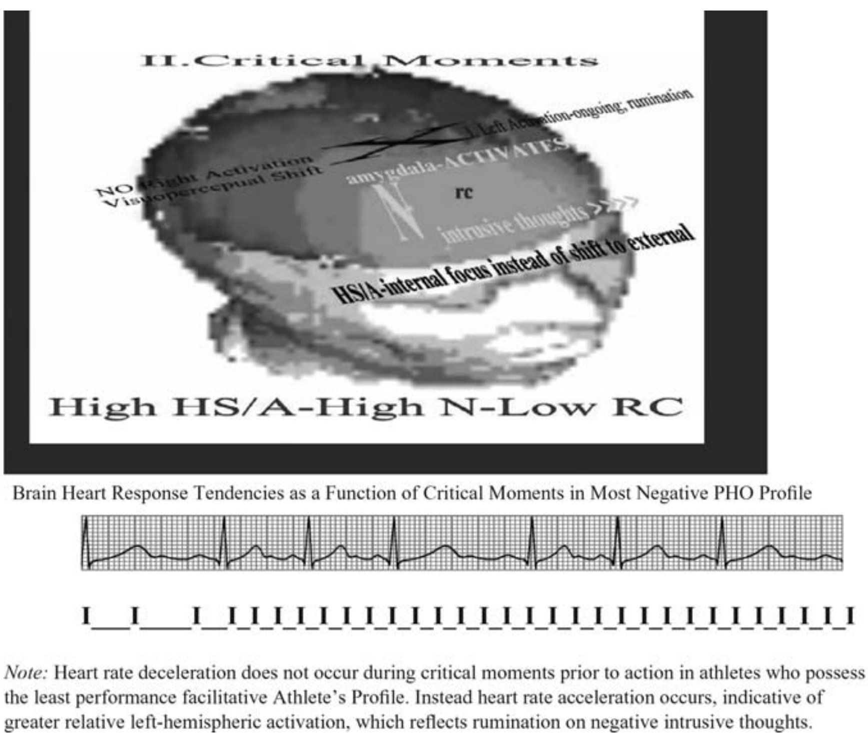


Figure 11.3 Cortical dynamics and heart rate variability during critical moment pre-action phase.

peak motor or technical ability. If they are concurrently high in hypnotic susceptibility/subliminal attention, their potentially superior ability to concentrate suddenly is directed inward toward negative thoughts and images and not on competitive tasks at hand. Such athletes are likely to see their games fall apart (see Figure 11.3).

On the other hand, athletes who thrive on and actually look forward to critical moments during competition usually have high levels of repressive/subliminal coping (left hemisphere based), are low in neuroticism/subliminal reactivity and either high or low in hypnotic susceptibility/subliminal attention (Carlstedt, 2004). These athletes have developed a protective psychological mechanism over the course of their career. Rarely, if ever, do they experience negative or self-defeating intrusive thoughts. They are self-assured and confident even in the most precarious of situations. If they are also concurrently high in hypnotic susceptibility/subliminal attention, their focus on task demands can be so intense they may not even recognize that a critical moment is imminent (indicative of "flow" or being in the "Zone"), allowing them to play free from constraining pressure and associated negative intrusive thoughts and general lack of focus. In such athletes the left-to-right shift that is observed during routine moments also occurs during critical moments. The "fight or flight" response is suppressed and negative thoughts are not generated. These athletes remain in total mind–body control that is marked by focused strategic

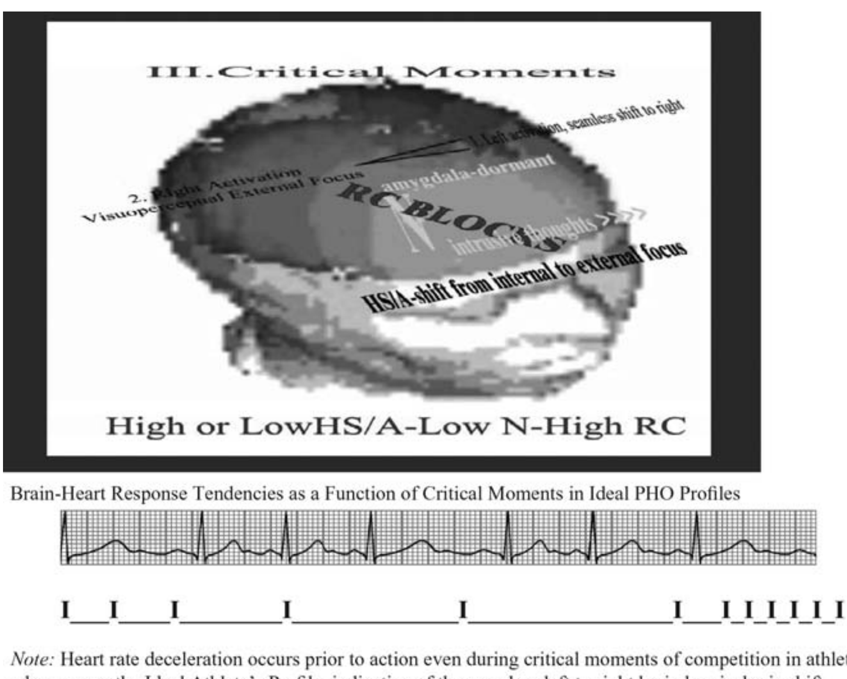


Figure 11.4 Cortical dynamics and heart rate variability during critical moment pre-action phase.

planning (left frontal region activation) followed (immediately prior to action) by visuo-perceptual attention to the impending task and motor priming (right frontal and motor cortex activation). This dynamic increases the probability that athletes will perform to their maximum physical and technical capabilities even during critical moments (Carlstedt, 2004).

Athletes possessing the ideal constellation of high repressive/subliminal coping, low neuroticism/subliminal reactivity and high or low hypnotic susceptibility/subliminal attention appear to be less vulnerable to negative intrusive thoughts, whereas athletes who are low in repressive/subliminal coping, high in neuroticism/subliminal reactivity and high in hypnotic susceptibility/subliminal attention are more vulnerable to disruptive cognitions, especially during critical moments of competition (Carlstedt, 2004).

Concomitant to shifts in brain hemispheric activity are specific parameters of heart rate variability. Most notably, during routine phases of competition, athletes in most sports exhibit heart rate deceleration (HRD) immediately prior to action (e.g. before serving, putting or shooting a free throw, batting and pitching in baseball) regardless of their constellation of PHO measures. By contrast, during critical moments, athletes possessing the most negative or disruptive constellation of PHO factors exhibit heart rate acceleration (HRA) prior to action, while those having the most facilitative or protective constellation continue to demonstrate HRD. HRA is associated with cognitive activity (e.g. thinking; intrusive thoughts) whereas HRD is associated with visuo-perceptual processing or orienting on or toward an important stimulus (like the ball). HRD is also more pronounced when right brain hemisphere and motor cortex activity increases after motor priming and strategic planning have taken place in the left frontal region (see heart activity tracers in the brain illustrations). Negatively predisposed athletes also exhibit increased muscle tension in secondary muscles that are not relevant to a specific technical demand (e.g. increased frontalis muscle activity when batting; see Carlstedt, 2004 for a review and references pertaining to the above mind-body dynamics).

Applying the CP to Elite Youth Team Baseball Players: Assessment, Intervention and Findings

The Carlstedt Subliminal Attention, Reactivity and Coping Scale-Athlete version (CSARCS-A) and Brain Resource Company (BRC) validated internet-based neurocognitive test battery were administered to all starting players (position players and key pitchers). The CSARCS-A is embedded in the comprehensive BRC online test package. Figure 11.5 depicts the resulting CSARCS-A, Athlete's Profile (PHO constellations) of the players. The "PHO Rank and Rating" cell contains the predicted, expected pressure response rating ranging from ***** (strongest) to – – (weakest) that is associated with the corresponding PHO constellation (**bold** = case study player).

Player	HS/SA	N/SR	RC/SC	PHO Rank and Rating
K	19 high-medium	8 low	6 low	8; **
R	18 high-medium	15 high	13 medium	10; ----
M	20 high-medium	8 low	18 high-medium	7; ***
JV	18 high-medium	6 low	24 high	3; ***
Y	5 low	3 low	23 high	1; *****
G	22 high	13 high-medium	11 low-medium	9; - - - -
MC	23 high	7 low	19 high-medium	4; ****
RJ	18 high-medium	2 low	17 medium	6; ***
S	21 high-medium	6 low	23 high	2; ****
J	15 medium	4 low	25 high	5; ***

Note: HS/SA = hypnotic susceptibility/subliminal attention; N/SR = neuroticism/subliminal reactivity; RC/SC = repressive coping/subliminal coping; High = high levels of trait; Med = medium levels; Low = low levels; Rating: ***** = Ideal; - - - - - = Worst; + = positive tendencies; – = negatively tendencies; N = neutral tendencies; PHO Rank indicates status of Athlete's Profile from 1, most performance to least facilitative.

Figure 11.5 Starting Player Athlete's Profile PHO constellations.

An interesting group finding regarding PHO profiles is that eight players scored low for neuroticism. That usually bodes well for a team when all things are about equal in the physical and technical realm. The predicted individual CM and psychophysiological (HRV) response tendencies can be compared to actual responses and performance in additional analyses below (Serial 7s stress test, CM performance; HRV pre versus intervention responses and HRV and performance outcome).

In-the-Laboratory Psychophysiological Stress Testing

Once an "Athlete's Profile" and neurocognitive tendencies have been established, it is desirable to go up a level in the evidence hierarchy. Since an athlete's constellation of Primary Higher Order Factors (PHO = hypnotic susceptibility/subliminal attention; neuroticism/subliminal reactivity; repressive/subliminal coping) is differentially associated with physiological reactivity, mostly as a function of one's level of neuroticism/subliminal reactivity, it is important to concurrently validate or criterion reference predicted with actual responses on standardized or commonly used stress tests. The Serial 7s backward counting test is used while measuring heart rate variability. Preliminary findings suggest that increases/decreases in specific heart rate variability measures from baseline to the test condition recording is a reliable predictor of physiological reactivity and subsequent critical moment performance tendencies (Carlstedt, 2007a). Especially baseline/test condition differences in low frequency/high frequency ratios have been found to be associated with critical moment performance. These differences tend to increase as a function of an athlete's level of neuroticism/subliminal reactivity, with the greater the low/high ratio being associated with subsequent poorer CM performace. Reactivity tendencies can also be teased out by using video feedback of an athlete's actual real competitive performance, with variable differential heart rate trends being observable as a function of one's "Athlete's Profile." For example, athletes who possess the most detrimental constellation of PHO factors (high HS/SA-high N/SR-low RC/SC) tend to exhibit more reactive HRV responses when they watch themselves encounter critical moments during competition. While this line of research is ongoing and Serial 7s stress testing needs to be validated preliminary results are promising and correspond with reactivity tendencies that one would expect on the basis of an athlete's PHO profile (Carlstedt, 2007a).

Starting Player Stress Test Responses

Procedure

Players were individually administered the Serial 7s Stress test prior to the commencement of the baseball season. Players were told to sit still and try to keep their minds blank while heart activity was recorded for two minutes. Thereafter players were instructed to count backwards out loud from 1000 by seven for two minutes (e.g. 1000, 993, 876...). Players were told to pick up the count if they stopped or made a (real or perceived) mistake in subtraction from the point of any error.

Instrumentation

The Biocom Technologies Heart Scanner software program was used for all HRV recordings and subsequent HRV monitoring and biofeedback procedures. Heart Scanner is a user-friendly hard and software system containing automatic artifact correction and report generation capabilities. A standard ear-lobe sensor is used to generate a cardiac signal that can be depicted in varying forms on different screens for monitoring, biofeedback, and analysis purposes. Recording time can be set from 1 to 30 minutes. Heart Scanner and other Biocom HRV programs meet research standards for reliability that were established by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996).

Figures 11.6 and 11.7 contain baseline and stress condition heart rate variability responses for starting players. Figure 11.8 lists differences in HRV responses across the baseline and stressor task and the players are ranked in order of greatest HRV Low/High frequency differences. Signs (e.g. + or −) in Figure 11.8 indicate whether stress responses can be considered consistent with what would be expected on the basis of a player's CSARCS-A, PHO constellation and to what extent (+++ = highly consistent; ++ = moderately consistent; + = consistent; −−− =

Player	HR	SDNN	VL	LOW	HIGH	L/H
K: HM-L-L	71	149	251	670	5460	0.1
R: HM-H-M	80	66	652	967	298	3.2
M: HM-L-HM	74	78	171	415	1032	0.4
JV: HM-L-H	76	169	79	6879	1420	4.8
Y: L-L-H	85	55	227	498	281	1.8
G: H-HM-LM	73	74	58	340	339	1.0
MC: H-L-HM	68	54	151	452	369	1.2
S: HM-L-H	85	116	63	3407	728	4.7
J: M-L-H	82	142	1684	289	236	1.2

Figure 11.6 Stress Test outcome: findings on starting players.

Player	HR	SDNN	VL	LOW	HIGH	L/H
K	83	66	81	575	847	0.
R	90	50	282	298	235	1.3
M	96	53	383	223	176	1.3
JV	79	108	197	1812	1638	1.1
Y	102	43	171	170	250	0.7
G	85	57	98	534	446	1.2
MC	92	62	596	439	252	1.7
S	95	46	116	488	172	2.8
J	85	60	132	468	305	1.5

Figure 11.7 Stressor: Serial 7s backward counting condition.

Player	HR	SDNN	VL	LOW	HIGH	L/H	PHO
K (19,8,6)	+12	–83	–170	–25	–4613	–0.1	**5+**
R (18,15,13)	+10	–15	–370	–669	–63	–1.9	**4 –––**
M (20,8,18)	+22	–13	+212	–192	–856	+0.9	**9–**
JV (18,6,24)	+3	–161	+118	–5067	+218	–3.7	**1 +++**
Y (5,3,23)	+17	–12	–56	–328	–31	–2.5	**2 +++**
G (22-13-11)	+13	–17	+40	+134	+107	+0.2	**6?**
MC (23,7,19)	+24	+8	+445	–13	–117	+0.5	**8––**
S (21-6-23)	+10	–70	+53	–2919	–556	–1.9	**4 +++**
J (15,4,25)	+3	–72	–1552	+179	+69	+0.3	**7–**

Figure 11.8 HRV differential and Athlete's Profile concordance.

highly inconsistent; –– = moderately inconsistent; – = inconsistent; 1-9 = change rank; ? = unsure due to ambiguous PHO profile.

Three players' stress responses (L/H) were highly consistent with what would have been expected on the basis of their Athlete's PHO profile and two were highly inconsistent with what would have been expected. High neuroticism (the second value in the Player cell) is usually associated with a greater shift to sympathetic activation as reflected in a positive L/H value (e.g. +0.9). Negative L/H values are indicative of relative parasympathetic predominance (less sympathetic reactivity). While the change from baseline to the stress condition has been associated with better critical moment (CM) performance at the group level, consistent with the IZOF model, ultimately micro-ecological statistical outcome measures will reflect actual CM performance. The above PHO Athlete's Profiles and stress test responses are illustrative, but interpretations should be made with caution. Ultimately one needs to rely on a multifaceted macro and micro statistical outcome measures to guide athlete assessment, with actual real situational performance, in the end, being the gold standard benchmark for establishing the criterion referenced and predictive validity of an assessment instrument.

Procedures during Official Games: Pre-intervention Phase

A psychophysiological monitoring station was set up in the dugout at each game site. The station consisted of two laptop computers that were loaded with Biocom Technologies Heart Scanner software. An ear sensor was connected to each computer. A trained analyst from the American Board of Sport Psychology (ABSP) summer Fellowship/Internship program was assigned to each computer for monitoring and intervention purposes. Another analyst was assigned to score the game in accord with standard baseball scoring and ABSP Critical Moment and Quality-of-at-bat/Quality of Pitch Psychological Proficiency methodologies. Coaches and players were briefed regarding the following procedures: (a) at the end of a defensive inning as players headed to the dugout to prepare to bat the names of three players were called out; the first batter to hit that inning, the second (on-deck) batter and the third (in-the-hole); (b) the first two players were called to one of the computer stations, were connected (hooked-up) to the computer via the ear sensor and then monitored and measured for HRV activity for one minute;[2] in the pre-intervention phase of the investigation players were told to "just sit there and try to remain still" while they were being monitored (view of the computer monitor was blocked); (c) after the one-minute was up the players were disconnected from the computer and they proceeded to the plate or on-deck circle as indicated; (d) thereafter, players who were in the three, four, or five batting order for that inning were alerted and told to be ready to report to the station for monitoring; this procedure was repeated until the inning was over. Pitchers were measured in a similar manner, once immediately upon coming off the mound and approximately ninety seconds to three minutes before returning to the mound to pitch the next inning depending upon the progression of the inning.

[2] While conventional clinical heart rate variability assessments are usually obtained from recordings that are no less than five minutes, HRV assessment can be adapted to the temporal parameters or constraints of a sport (e.g. length of a time-out when HRV measuring takes place). As such, in baseball one-minute recordings are used. Although, this is not an optimum time period (two-minutes is the minimum recommended recording period) short time recordings can be used. However, the very low frequency HRV domain may be inaccurate when recordings last less than two minutes (Perlstein, 2007, personal communication). This limitation was taken into account when analyzing the data.

Figure 11.9 Sample photo of the data collection (pre-intervention) phase on the bench prior to batting.

The pre-intervention phase lasted for 13 games and was exclusively concerned with determining players' psychophysiological (HRV) response tendencies (IZOF) prior to batting or pitching as a function of differential criticality (situational pressure).

Procedures During Official Games: Intervention Phase

The logistics of the intervention were very similar to the pre-intervention phase with the exception that the monitor was viewed by players (to observe their own HRV activity) for shaping/inducing a specific biofeedback response.

The Intervention: "Lock-In"-HRD/HRV Biofeedback Protocol

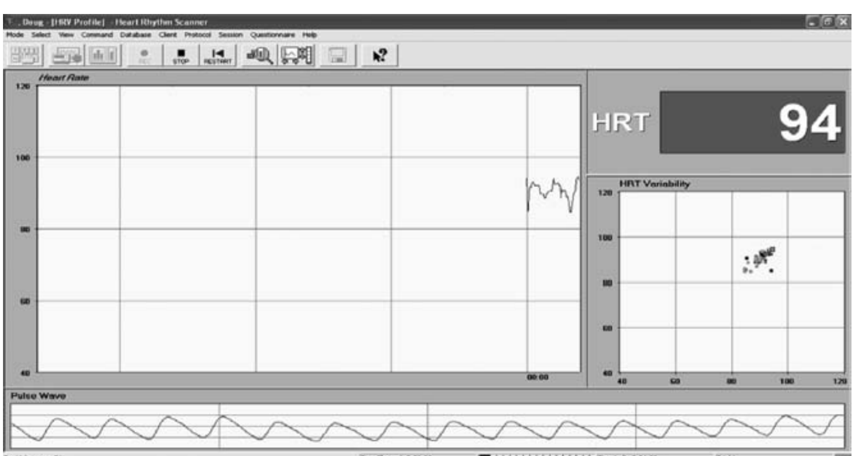
Players were briefed on the mind-body-motor relevance of HRD. They were told to think in terms of learning to regulate or induce specific levels or states of activation, in this case timed breathing to set off the HRD cascade of mind-body-motor responses that have been linked to peak performance. Consequently, position players were trained to time their inhale and exhale cycles with the impending onset of the pitch from the pitcher. Inhalation was timed to coincide with the pitcher's wind-up, with exhalation occurring rapidly (and linearly) as soon as the pitcher released the ball toward the plate (batter). By contrast, pitchers were trained to time their inhale cycle with the onset of their wind-up and exhale cycle with the release of the ball. In both instances, conceptually, inhalation is associated with heart rate acceleration (HRA is known to occur when cognitively engaged such as during the pre-action strategic planning and motor priming that takes place prior to pre-action when hitting or pitching) and exhalation with HRD (see HRD section above). HRD prior to the onset of action is expected to suppress intrusive/superfluous thoughts and facilitate focus, technical priming and subsequent coordinated motor responses.

To increase awareness of this cardiac dynamic and practice the HRD "Lock-In" breathing cycle players were taken through three stages of mental training commencing with (1) HRD-breathing biofeedback at the computer station in the dugout for one minute, followed by (2) a continuation of the prescribed breathing process in the on-deck circle while taking batting swings (cuts) that were timed to the pitcher's pitching rhythm (practicing the HRD protocol while watching the pitcher pitch to the current batter). Finally, players attempted to apply the entrained HRV-biofeedback technique when batting, timing their inhale-exhale cycles with the pitcher's rhythm (during a real at-bat). While conscious efforts to induce specific psychophysiological responses can have a paradoxical effect initially (and lead to performance decrements), over time, it is expected that HRD will be set off independent of any conscious efforts to do so (see PHO-HRD charts, Figures 11.2, 11.3 and 11.4, as a function of criticality) due to repetition and the eventual consolidation of long term procedural memory. It should be noted that HRD and concomitant cortical responses occur routinely, anyway, independent of conscious attempts to control it, especially in the absence of competitive stressors in virtually all athletes. However, more vulnerable athletes who are negatively predisposed (with the most negative PHO constellations), when facing increasing criticality (or pressure; whether real (based on objective statistical metrics) or perceived) are more likely to exhibit mind-body-motor responses that are incongruent with the HRD (e.g. HRA and reduced motor control, slower reaction time). It is thus expected that this subset of negatively predisposed athletes will need mental training the most. Nevertheless, in this investigation all players engaged in the protocol throughout the intervention phase of the season.

The "Lock-In" – HRD Biofeedback: Step-by-Step

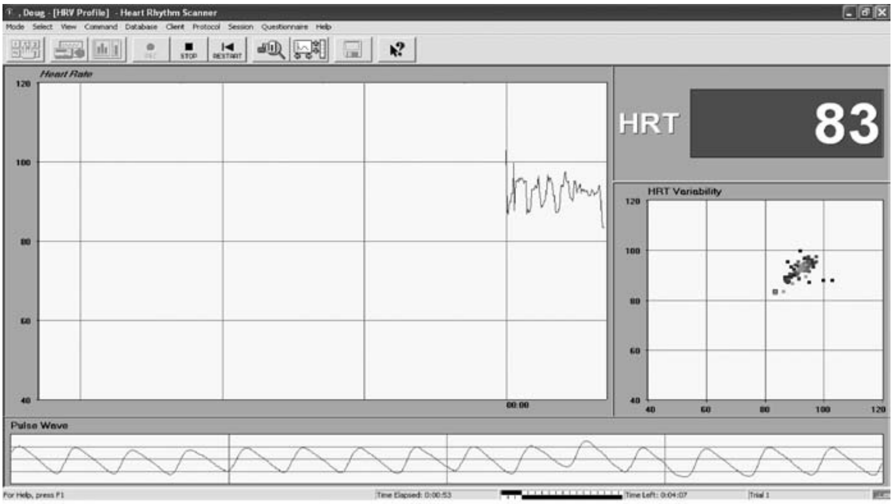
Consistent with the team's schedule (comprised almost exclusively of official league games and no formal practice/training sessions between games) the prescribed HRV-biofeedback protocol could only be formally practiced under controlled and supervised conditions before each game for about 5–10 minutes as feasible. Training was augmented using the *Stress Eraser* device to further help entrain the prescribed breathing pattern (each player was given this instrument to use on their own for the entire season). The intervention was designed to induce a so-called "Lock-in" state immediately prior to action whereby players attempted to induce heart rate deceleration (HRD) that is associated with enhanced attention, faster reaction times and improved motor/technical performance (review above on PHO measures and HRD-cortical responses). The goal of this form of mental training is to circumvent hard to assess and document interventions like mental imagery or generic biofeedback procedures like progressive relaxation or respiratory sinus arrhythmia (RSA; that have not been validated in sport), with a method that has been directly associated with the initiation of a cascade of performance facilitative mind-body-motor responses that have been shown to underlie peak performance.

1. Player goes to Lock-In Monitoring and Biofeedback station.
2. Player is hooked up to ear sensor and computer.
3. Player is instructed to breathe in and attempt to raise the digital heart rate indicator on the computer screen as high as possible (e.g. from 75 bpm to 100 bpm) with one long breath (inhalation cycle; see following screen shot).
4. Player is then instructed to rapidly exhale once the HRA apex has been attained until the lowest heart rate number has been reached (HRD); the exhale cycle should be fast and progressive to induce the uninterrupted, linear cardiac cycle slowing trend (e.g. 100, 95, 90, 85 bpm) that has been associated with faster reaction time and improved performance.
5. Player is instructed to pause for a few seconds after each HRD timed breathing cycle and then repeat until the one-minute monitoring epoch is over.
6. Player is instructed to attempt to time HRD breathing cycle with the pitching rhythm that will be encountered and visualize the impending at-bat and pitch sequences.
7. Player is instructed to go to the on-deck circle after the on-bench HRV biofeedback and assume a stance that allows for the observation of the pitcher's pitches to the batter that is hitting (while waiting to go to bat); during the on-deck phase the player is instructed to take timed cuts (practice swings) with



Note: Notice the rising line or curve on the far right side of the tachogram that is associated with inhalation mediated heart rate acceleration.

Figure 11.10 Outtake of inhalation and exhalation cycles with induced heart rate reading.



Note: Notice the falling line or curve on the far right side of the tachogram, which is associated with exhalation mediated heart rate deceleration.

Figure 11.11 Outtake of inhalation and exhalation cycles with induced heart rate reading.

concomitant HRD timed breathing (timed to pitcher that is being observed while taking practice swings); that is, when the pitcher starts the wind-up (precursor to actual pitch) the player is told to calibrate the inhale cycle and start the exhale cycle as soon as the pitcher's hand starts to release the ball; note: the on-deck HRD practice phase is a crucial step in establishing and synchronizing the HRD inhale-exhale cycles to the pitcher's pitching rhythm.

8. Player is instructed to implement the HRD-"Lock-In" breathing procedure when in the actual batter's box when at bat, remembering to inhale and exhale as a function of the pitcher's pitching rhythm.
9. Steps 1–8 are repeated throughout the game's batting cycles for each player.

Critical Moment Analyses

An integral and crucial component of the CP is the measurement and assessment of psychological performance as reflected in critical moment statistics. Critical moments (CM) are operationalized as increasing levels of sport-specific situational importance. Criticality levels range from 1 (lowest level of importance in terms of being able to impact match/game outcome) to 5 (highest level of importance) with increasing level of criticality expected to induce greater competitive stress or pressure/stress responses in athletes especially as a function of an athlete's PHO profile. A criticality rating (CM) is assigned to each competitive moment of a specific sport (e.g. each point in tennis, shot in golf, or at-bat in baseball). The level of criticality of a competitive moment is determined by expert raters. Validation research has shown that increasing criticality in baseball is overwhelmingly associated with decreased performance. The linear relationship between heightened criticality and performance decrement has been established in numerous sports including soccer, basketball, golf, tennis and baseball (an initial baseball validation study involved an analysis of over 600 major league baseball games; 2000 at-bats; Szuhany, Carlstedt, and Duckworth, 2009). An ideal Athlete's Profile constellation can mitigate this decrement, but in studies of criticality in baseball mental toughness is associated more with the degree of lesser performance decrement (less of a negative correlation). Only two major league baseball players exhibited a positive correlation between criticality and quality of bat in the aforementioned study. *All* other players performed differentially worse as a function of increasing criticality (Szuhany, Carlstedt, and Duckworth, 2009).

Critical moment performance statistics were used to assess psychological performance in the context of pre-intervention and intervention-based batting and pitching (quality of at-bat and quality of pitch) and psychophysiological measures (HRV). Intervention efficacy was determined on the basis of micro-level predictor measures (e.g. level of criticality) and their statistical relationship with micro-level criterion/outcome measures (e.g. quality of bat; batting average with "men" in scoring position). Micro-outcome measures (performance statistics of a specific sport) are usually much more sensitive than more global or macro-level criterion variables in establishing relationships between psychological, behavioral, psychophysiological, and personality measures and performance (Carlstedt, 2004). Nevertheless, global, macro outcome measures such as batting average were also analyzed in the context of pre and intervention phases of this study.

Critical moments were investigated as follows (pre intervention and intervention phases):

1. the effect of level of criticality on quality of at-bat;
2. the effect of level of criticality on HRV.

The following relationships were also investigated:

1. the effect of HRV and intervention induced HRV on conventional baseball batting outcome measures and quality of at-bat as a function of level of criticality;
2. performance differences between pre-intervention and intervention as a function of level of criticality and HRV differences between pre and intervention performance as a function of biofeedback and level of criticality.

Findings

Figure 11.5 reveals macro-level team outcome findings across pre and intervention phases. Thereafter criticality, Athlete's Profile and Individual Zone of Optimum Functioning and performance relationships and findings will be presented.

Games won versus games lost are the first and most noticeable, and arguably the most important outcome measure in a team sport. It is thus tempting on the basis of

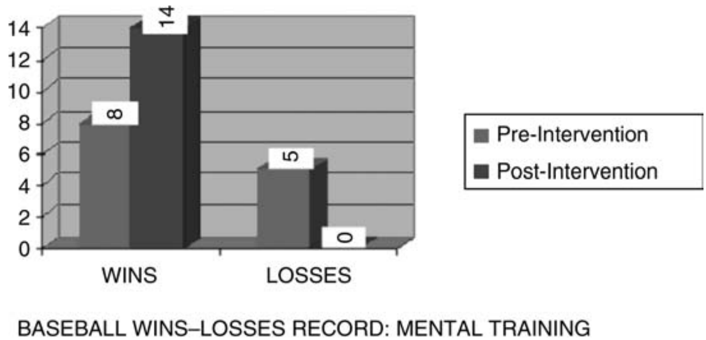


Figure 11.12 Team baseball statistics: pre-intervention vs. intervention won-lost record.

the vast improvement from the pre (nonintervention) to the intervention phase to attribute such success to the HRD, "Lock-In" biofeedback protocol. While this team's performance leap is highly suggestive it does not establish causality between the intervention and outcome. Nevertheless, it is much better (and motivating) to observe statistical improvement over time in a quasi-controlled and ecological intervention paradigm, especially since formal training or practice (working on baseball skills) was virtually nonexistent throughout the season due to the team's demanding game schedule (a game or two 6–7 days a week), than have a team exhibit a worse record after an mental training phase. Although playing lots of games over a concentrated period may have had a psychologically stabilizing effect and enhanced batting skills, the only controlled difference between the pre and intervention phases was the actual intervention. As such, one could maintain that the "Lock-In" component of the CP had a positive effect on overall team performance. Additional macro-level baseball-specific performance statistics lend further support to this preliminary conclusion. For example, team batting average, on-base and slugging percentage were higher in the intervention phase.

Although the conventionally used *p* value threshold for determining statistical significance may have not been met when comparing some of the above macro-level batting statistics, statistical significance frequently takes a back seat to practical significance in sports and especially baseball where an absolute numeric gain can

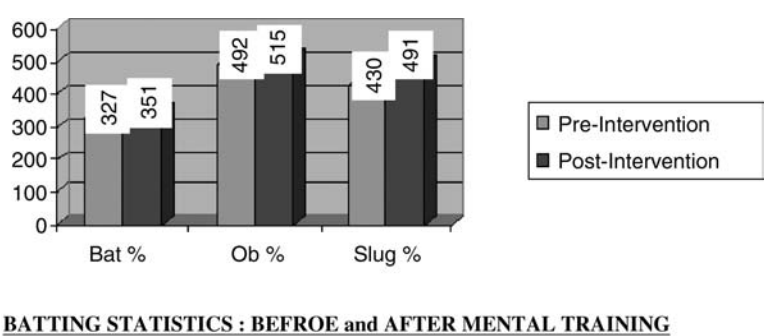


Figure 11.13 Pre-intervention vs. intervention baseball performance statistics.

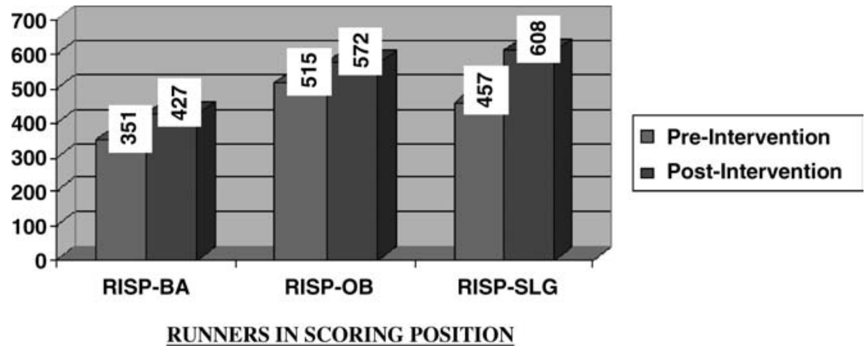


Figure 11.14 Team "Mental Toughness" statistics: pre-intervention vs. intervention.

speak volumes and even impact the value of a player's contract or the security of a manager or coach's job. Relative to this team's aggregate batting average, going from 0.327 to 0.351 could mean the difference between winning or losing two or three more games and finishing in first as opposed to second place in the standings. Nevertheless, irrespective of the statistical versus practical significance issue, additional findings below reveal performance gains in the intervention phase that have both statistical and practical significance. More micro-level findings include so-called "Crunch-time" statistics that, anecdotally, are thought to reflect "mental toughness," another overused and under-operationalized sport psychological buzz-phrase. Yet, if we accept common notions about "clutch" or "mental toughness" the following team findings also revealed impressive gains in the intervention phase. Batting average, on-base and slugging percentage with runners in scoring position went up significantly in the mental training phase.

Case Studies: Relationships between Heart Rate Variability Components and Batting Performance and Pre-Intervention vs. Intervention Batting Performance

Figure 11.17 depicts player mind-body responses before and during mental training. Although conceptually, the construct validity for the "Lock-in" HRD intervention is based on research that has isolated key cognitive (mind) and heart-brain-motor interactions prior to and as action commences, and would be the preferred predictor measure for determining real-time associations between HRD and performance outcome, the aggregate HRV data that is generated over a one-minute monitoring period during "time-outs" (on-the-bench before batting or pitching) has emerged as a predictor of performance in its own right. In other words, although the "Lock-in" intervention, if carried over into the batting box (from the computer station on the bench), was designed to set off a cascade of performance facilitative mind-body-motor events related to breathing mediated HRD, total HRV and its time and

Figure 11.15 Nexus 32 telemetry system used to validate pre-action heart rate deceleration while batting in baseball and isolated HRD epoch.

frequency domain components that are acquired on-the-bench for one-minute have been shown to predict performance and explain "x" amount of the variance in the performance equation that can be attributed to a psychophysiological measure (pre-intervention phase) or biofeedback shaped psychophysiological response (intervention). Even though nonintervention HRV or manipulated HRV biofeedback response profiles within this methodological paradigm are temporally isolated outside the context of actually batting, that is, not time-locked to the real pre-action pitching-batting epoch, these measures have exhibited predictive strength and emerging player Individual Zone of Optimum Functioning (IZOF, Hanin, 1980) profiles as a function of nonintervention baseline and biofeedback induced responses. I propose that this one-minute period of autonomic nervous system (ANS) responding (IZOF HRV

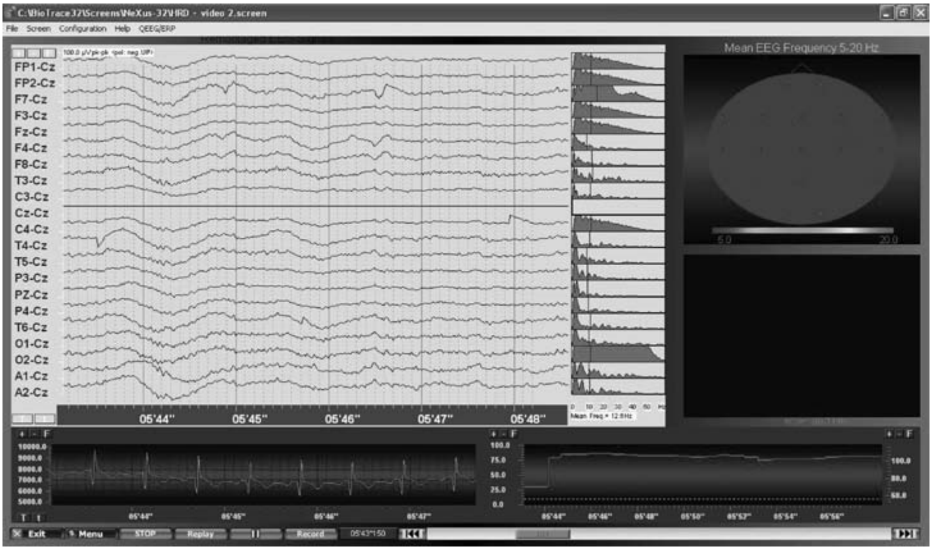


Figure 11.16 Source EEG and EKG tracings with isolated HRD epoch.

response profile) can generalize to the playing field and may influence eventual pre-action response tendencies (entrainment of HRD response that was practiced using biofeedback). Consistent with predictions from the IZOF, pre-action response tendencies can be quite disparate across individuals, with athletes who manifest even diametrically opposite one-minute HRV response profiles, performing differentially from what might be expected (e.g. heart rates of 70 and 120 being associated with equally good performance outcome or vice versa).

Pre-Intervention HRV

Determining intervention efficiency and efficacy

Figures 11.17–11.19 contain player response data pertaining to intervention efficiency and efficacy. Intervention efficiency can be operationalized as the magnitude of change in key HRV measures between a nonintervention and intervention condition. Relative to the “Lock-in” HRD protocol, the prescribed timed breathing cycles are expected to initially induce a HRA phase (linearly increasing heart rate), followed immediately by HRD and its concomitant linearly decreasing heart rate. As such, it is hypothesized that an individual engaging in this protocol correctly will exhibit a significantly greater heart rate variability index (SDNN) than individuals who are breathing in accord with their natural or developed situational breathing patterns. Thus, SDNN (Sd below) is expected to be the predominant pre versus post HRV change measure in the context of this biofeedback protocol. Other HRV

Player	Sdpre	Sdpo	Sddif	L:Hpre	L:Hpo	L:Hdif	PHO
K: HM-L-L	76	94	+18 (6)	0.74	4.1	+3.36 (4)	+22.1 – 6
R: HM-H-M	74	79	+5 (7)	0.93	3.0	+2.07 (6)	+7.1 + 7
M: HM-L-HM	57	88	+21 (4)	1.5	3.9	+5.40 (3)	+26.4 + 4
JV: HM-L-H	63	82	+19 (5)	2.3	8.1	+5.80 (2)	+24.8 +++ 5
Y: L-L-H	51	92	+41 (1)	6.3	7.4	+1.1 (7)	+42.1 +++ 2
G: H-HM-LM	44	71	+27 (3)	2.2	4.9	+2.7 (5)	+29.7 –– 3
MC: H-L-HM	67	64	–3 (9)	1.6	2.5	+0.9 (8)	–2.1 – 9
S: HM-L-H	127	117	–10 (10)	3.3	2.8	–0.5 (10)	–10.5 – 10
J: M-L-H	66	103	+37 (2)	2.5	9.6	+7.1 (1)	+44.1 +++ 1

Note: pre = pre-intervention; po = intervention; dif = difference pre vs. intervention; Sd = SDNN; L:H = low-high frequency ratio; PHO = primary higher order constellation with magnitude of change between pre and intervention (sum of Sd and L:H change); Signs (e.g. + or –) in the third chart indicated whether stress responses can be considered consistent with what would be expected on the basis of a player's CSARCS-A, PHO constellation and to what extent (+++ = highly consistent; ++ = moderately consistent; + = consistent; – – – = highly inconsistent; – – = moderately inconsistent; – = inconsistent; 1-9 = change rank; ? = unsure due to ambiguous PHO profile).

Figure 11.17 Intervention induced HRV changes: Hypothesized key measures related to HRD entrainment efficiency as a function of PHO constellation.

measures may emerge individually as a function of a person's IZOF. However, irrespective of biofeedback induced changes in HRV measures, ultimately, intervention efficacy must be determined independently of hypothesized efficiency parameters (see Figures 11.17 and 11.18). Nevertheless, it is important to determine to what extent a biofeedback technique is actually being engaged in by an athlete as reflected in changes from the baseline to intervention condition. It should be noted that intervention efficiency is expected to be affected by an individual's PHO constellation. Previous research suggests that individuals who are lower in hypnotic susceptibility (subliminal attention) and higher in repressive coping (subliminal coping) are more likely to induce greater psychophysiological changes when engaged in biofeedback. The players' PHO constellation is listed next to their identifying initial and their biofeedback mediated total change in HRV measures is notated in the PHO column along with a consistency notation (degree of concordance with what would be expected on the basis of PHO constellation).

An intervention efficiency index was arrived at by adding the difference in responding in two HRV measures that are expected to vary (increase) the most from the pre-intervention baseline state to the intervention, namely, SDNN (the HRV index; Sd above) and L:H frequency ratio. Shifts toward greater change in HRV (SDNN) and less of a L : H ratio are hypothesized to reflect greater autonomic nervous system control and the likelihood that the HRD "Lock-in" protocol will be successfully generalized to the batting box. Six out of nine players demonstrated a level of intervention efficiency that would have been predicted on the basis of their Athlete's Profile PHO constellation. It should be again noted that intervention efficiency does not necessarily predict intervention efficacy. While it might be expected that players who have learned and demonstrated specific biofeedback responses prior to a sport-specific task will be capable of exhibiting them prior to action (e.g. when batting) one cannot determine with certainty whether this is the case and even if they do, that performance gains will be achieved and to what extent. Such must be determined using the CP intervention efficacy methodology that attempts to explain the amount of variance in various performance outcome measures that can be attributed to an intervention entrained or induced predictor measure like HRD or some other HRV measure (e.g. SDNN, see next section).

Intervention efficacy

Intervention efficacy can be established both on the basis of more global macro-level (nonpsychophysiological, pre-intervention vs. intervention gains in sport-specific statistical categories) and micro-level associations between one-minute HRV biofeedback manipulated response profiles and CM mediated sport-specific statistical categories. It should be noted that an HRD study during an official tennis tournament using Polar instrumentation clearly delineated pre-action HRD and linking greater amounts and magnitude of HRD to enhanced performance (Carlstedt, 1998, 2001b). This study supported the hypothesis that a one-minute HRD biofeedback intervention that is engaged in prior to returning to the playing field will increase the likelihood of successfully self-inducing HRD prior to action through a timed breathing technique, and that the efficacy of such attempts will be reflected in macro and micro-level statistical outcome measures. Obviously, ultimately, a more direct real-time measurement of HRD during actual batting is desirable. A real-time HRD paradigm for baseball and tennis using the Nexus 32 telemetry EEG system has been piloted (see above) and plans are in place to attempt

Player/Profile	**Pre-Intervention(CM→QAB)**
K (19,8,6) 8	0.232 +
R (18,15,13) 10	0.205 –––
M (20,8,18) 7	0.164 ++
JV (18,6,24) 5	0.162 ++
Y (5,3,23) 1	0.134 ++
G (22,13,11) 9	0.130 –––
MC (23,7,19) 4	0.079 +
S (21,6,23) 2	–0.074 –––
J (15,4,25) 3	–0.175 –––

Note: Pre-Intervention Criticality (CM) and Quality of at-bat (QAB); numbers 1–10 = ranking of PHO constellation from most to least performance facilitative with actual Athlete's Profile PHO scores in parentheses Signs (e.g., + or –) in the third chart indicated whether stress responses can be considered consistent with what would be expected on the basis of a player's CSARCS-A, PHO constellation and to what extent (+++ = highly consistent; ++ = moderately consistent; + = consistent; – – – = highly inconsistent; – – = moderately inconsistent; – = inconsistent; 1-10 = change rank; ? = unsure due to ambiguous PHO profile.

Figure 11.18 Pre-intervention criticality performance.

Player	Intervention(CM→QAB)
MC (23-7-19)	0.218 +++
S (21-6-23)	0.184 +++
K (19-8-6)	0.165 +
G (22-13-11)	0.090 +
JV (18-6-24)	0.024 –––
R (18-15-13)	0.020 ++
J (15-4-25)	–0.022 +++
Y (5-3-23)	–0.052 –––
M (20-8-18)	–0.102 –––

Note: Intervention Criticality (CM) and Quality of at-bat (QAB); Signs (e.g., + or –) in the third chart indicated whether stress responses can be considered consistent with what would be expected on the basis of a player's CSARCS-A, PHO constellation and to what extent (+++ = highly consistent; ++ = moderately consistent; + = consistent; ––– = highly inconsistent; –– = moderately inconsistent; – = inconsistent.

Figure 11.19 Intervention criticality performance.

to validate real-time HRV/HRD responses in official baseball games in 2011 using the Polar system. Nevertheless, the extant CP HRD paradigm still allows for the objective quantification of mind-body response tendencies during time-outs (in the dug-out or on the bench) and determining their subsequent impact on performance on the basis of associations between one-minute HRV epoch ANS response profiles.

In the pre-intervention phase five out of nine players performed as would have been predicted on the basis of their Athlete's Profile PHO constellation as a function of CM. In contrast to major league baseball players, these elite youth players, overall, performed better than their professional counterparts when under pressure (CM), with most players being over the zero threshold (less than 0 = negative association between criticality and quality of at-bat). This can likely be attributed to the dominance of pitching in professional baseball. Nevertheless, even with this youth team, performance decreased significantly in all players as a function of rising criticality. By contrast routine moments batting performance improved in the intervention phase. Such disparate findings point to the need to analyze both macro and micro level competitive moments to arrive at more accurate intervention efficacy assessments.

Player	Differential (pre-post)
J (15-4-25) +++	0.153
MC (23-7-19) +++	0.139
S (21-6-23) +++	0.11
G (22-13-11) ++	–0.04
K (19-8-6) +++	–0.067
JV (18-6-24) –––	–0.138
R (18-15-13) +	–0.185
Y (5-3-23) –––	–0.188
M (20-8-18) ––	–0.266

Note: Change differential as a function of Outcome Measure = Quality of at-bat from pre to intervention phase as expressed in "***r***" (correlation coefficient) Signs (e.g., + or –) in the third chart indicate whether stress responses can be considered consistent with what would be expected on the basis of a player's CSARCS-A, PHO constellation and to what extent (+++ = highly consistent; ++ = moderately consistent; + = consistent; – – – = highly inconsistent; – – = moderately inconsistent; – = inconsistent; 1–10 = change rank.

Figure 11.20 Pre vs. intervention criticality performance differential (change).

Since one expects that an intervention will help athletes master CM it can be disconcerting to athletes, coaches, and sport psychologists when that is not the case. For example, with this team only four players made pre versus post (intervention) gains in quality of at-bat as a function of increasing criticality. However, performance decrements in the intervention phase, especially in the context of micro-level measures like criticality (CM), can happen; yet such instances do not necessarily call into question the validity or potential potency of an intervention. There may be explanations for unexpected intervention effects. With this team variability of CM was quite limited with significantly more CM level 1, 2, or 3, than levels 4 or 5 (the highest levels that are conceptually associated with the greatest amount of competitive stress) occurring. Thus, in order to arrive at a more accurate assessment of CM performance a sufficient *N* of CM level 4-5 at-bats are needed (statistical power). Hence, in cases where there is an insufficient amount of a particular micro-level measure to arrive at valid statistical inferences one must revert to more macro-outcome measures such as batting average and other conventional batting statistical changes in order to arrive at interpretations of intervention efficacy.

Select Case Studies

Player R

Intervention Efficiency: +7.1 (ranging from −2.1 to +44)
Pre-Intervention (CM → QAB): 0.205
Intervention (CM → QAB): 0.020
Differential (pre-post): −0.185
Pre-Intervention (CM → SUC): 0.116
Intervention (CM → SUC): −0.035
Differential (CM → SUC) pre-post: −0.151
Player Criticality and HRV Response and Outcome Association Findings (Micro-level):
Pre-Intervention: CM and POW 0.31; CM and LF 0.33

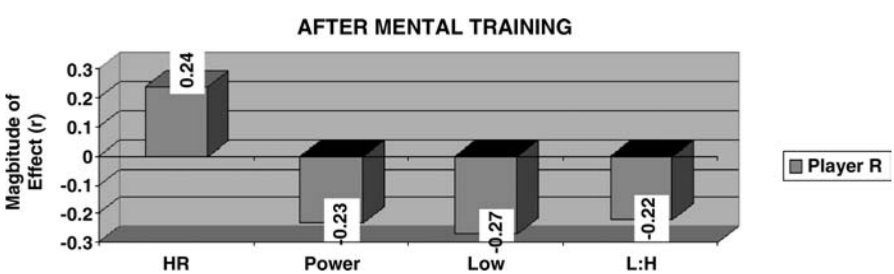


Figure 11.21 Intervention HRV and outcome.

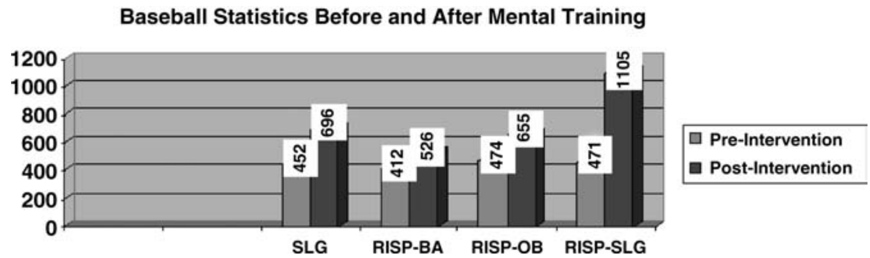


Figure 11.22 Pre vs. post statistical performance differences.

Player R had no HRV measures associated with the performance outcome measure "Success" during the pre-intervention phase of the season. "Success" is operationalized as a hit of any kind (single, double, etc.). Relationships between HRV measures and outcome are investigated using correlational and regression statistical methods. Having "no" HRV components associated with the "Success" outcome measure means that no statistically significant correlations could be found between the predictor and criterion measures (HRV and "Success"). From an interpretive perspective, in such a case where no relationships emerged in the pre-intervention baseline phase but did in the intervention phase, one can at minimum assume that the prescribed intervention routine indeed changed a player's underlying psychophysiology. This was further substantiated in the previous pre and intervention (efficiency and efficacy charts, Figures 11.17 and 11.18). As to whether such changes were associated with enhanced performance and to what extent must then be determined on the basis of the variance explained metric (micro-level direct relationship between HRV and outcome) and macro-level pre versus post comparisons of sport-specific statistical outcome measures (player R's baseball stat can be found above).

In the mental training phase player R's HR was associated with better outcome ($r = 0.24$) and explained about 6% of the variance in successful hitting. This means that in the one-minute "Lock-in" mental training epoch, the HR component of the HRV response profile predicted subsequent actual batting performance; with greater heart rate during the intervention being associated better performance. One should be aware that although an *r* of 0.24 and 6% of the variance may seem to not reflect a strong association, when viewed in context of variance explained in sport performance that can be attributed to all psychological variables combined (whether, trait, behavioral or psychophysiological measures) that have yet to exceed 10% of the variance (Carlstedt, 2001, 2004), 6% for one HRV component is quite impressive, especially in light of its temporal distance from the actual performance event (a measure obtained 1–3 minutes before batting).

Three other HRV components were associated with poorer performance including total frequency domain Power (P), Low frequency activity (L) and the ratio of low to high frequency (L:H), meaning, the greater amount of these measures the lower the rate of success. Disparate findings in which one or more HRV component is associated with successful performance and others with negative outcome may seem paradoxical, however, they can be explained on the basis overall low success rates that occur in baseball where a 30% batting average is considered good. Hence with significantly more failure being the norm it is possible that specific HRV components emerge to negatively impact performance independent of positive associations between HRV and outcome. While correlational and regression relationships reflect linear associations, the ultimate goal of an intervention is to shape or enhance IZOF HRV response components that are associated with successful performance and suppress IZOF HRV response components that are shown to have a negative impact on performance. In the case of player R, his IZOF HRV profile suggests that HRA may have been predominant in the on-the-bench intervention leading to the generation of more sympathetic nervous system (SNS) activation and subsequently more HRA when actually batting, especially when he did not get a hit (when unsuccessful). Relative to Criticality (Critical Moments) in the pre-intervention phase Power and Low frequency HRV were positively correlated with Criticality ($r = 0.31$ and 0.33 respectively, explaining about 10 and 11% of the variance in HRV that could be attributed to criticality).

Athlete's Profile: Subliminal Attention: MEDIUM; Subliminal Reactivity: MEDIUM; Subliminal Coping MEDIUM
These findings and all other case study findings were based on over 60 at-bats (> 60 on-the-bench intervention sessions prior to batting) lending good statistical power to the data.

Player M

Intervention Efficiency: +26.4
Pre-Intervention (CM → QAB): 0.164
Intervention (CM → QAB): −0.102
Differential (pre-post): −0.266
Pre-Intervention (CM → SUC) 0.228
Intervention (CM → SUC): −0.233
Differential (CM → SUC pre-post: −0.461
Player Criticality and HRV Response and Outcome Association Findings (Micro-level):
Pre-Intervention: CM and SDNN −0.309; CM and HF −0.283

This power hitter struggled in the first half of the season. During mental training his slugging performance increased significantly especially with runners-in-scoring position consistent with his high intervention efficiency rating +26.4. Increasing heart rate (HR) in the intervention phase was associated with better performance. By contrast four other HRV measures emerged as having a negative effect on performance during the intervention phase. Again, disparate influences of HRV on performance (some positive, others negative) can be attributed to the overall

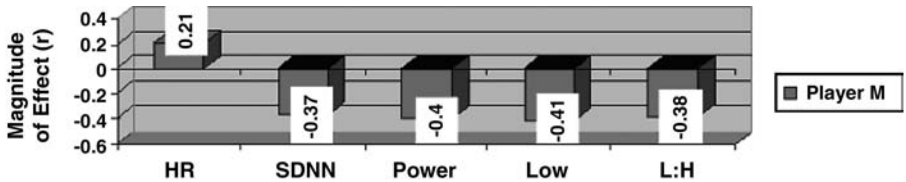


Figure 11.23 Pre-intervention HRV and outcome.

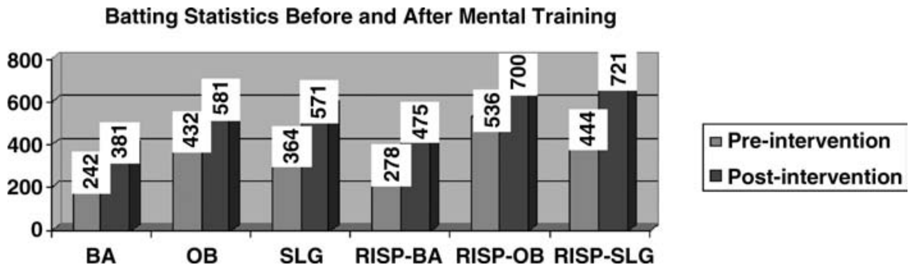


Figure 11.24 Pre vs. post statistical performance differences.

low success rates associated with batting, increasing the likelihood that specific psychophysiological response tendencies will impact this hitting adversely.

Relative to criticality CM influenced SDNN (−0.309) and HF (−0.283); about 10% and 8% of the variance in these HRV measures in pre-intervention phase respectively that could be attributed to criticality. No HRV measures emerged in the intervention phase as effected by CM.

Athlete's Profile: Subliminal Attention: MEDIUM; Subliminal Reactivity: LOW; Subliminal Coping MEDIUM

Player J

Intervention Efficiency: +44.1
Pre-Intervention (CM → QAB): −0.175
Intervention (CM → QAB): −0.022
Differential (pre-post): 0.153
Pre-Intervention (CM → SUC): −0.069
Intervention (CM → SUC): −0.154
Differential (CM → SUC pre-post: −0.185
Player Criticality and HRV Response and Outcome Association Findings (Micro-level):
Pre-Intervention: CM and SDNN 0.59 Intervention: CM and HR −0.253

This player is on the cusp of having the best athlete's profile and despite not being as physically and technically developed as some of his teammates made major gains

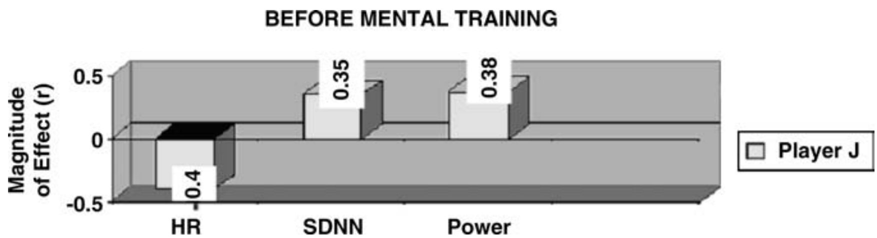


Figure 11.25 Pre-intervention HRV and performance.

Figure 11.26 Intervention HRV and performance.

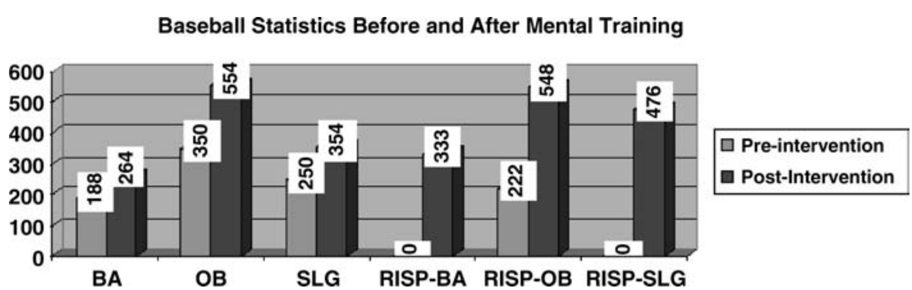


Figure 11.27 Pre vs. post statistical performance differences.

in all statistical categories, especially pressure performance during the mental training phase of the program. True to predictions he performed as one would expect of a player with this Athlete's Profile PHO constellation. Mental training can still help even positively predisposed athletes enhance their performance, especially in baseball, where pitching can be very dominating and capable of negating any psychological advantage that a player may have. As such, the "Lock-in" HRD protocol, that is designed to facilitate not only focus but faster reaction time, may assist the mentally tough athlete, help enhance attention and reaction time, and to a certain extent mitigate the advantage pitchers tend to have, responses that are crucial to successful hitting. By locking in on the ball and priming the motor system for action, a mentally tough player possibly becomes tougher, especially ones who are still developing technically. Note also that this player had HRV measures emerge as being associated with better performance during the mental training phase and in the context of CM during the nonintervention phase (Mental training phase: SDNN, Power and Low frequency HRV). The strong correlation between pre-intervention SDNN was consistent with what would be predicted on the basis of this player's PHO profile and suggestive of a naturally or developed timed breathing pace that is synchronized to the temporal properties of the pre-action pitching-batting epoch in baseball ($r = 0.59$) independent of consciously attempting to generate a specific breathing pattern. A correlation coefficient of 0.59 equals about 35% of the variance in batting success that can be attributed to a psychophysiological measure, in this case SDNN, the HRV index. This is a remarkable finding that lends further support to the Athlete's, Critical Moments, and IZOF models of peak performance. Relative to Criticality, in this player, HR was negatively correlated with increasing criticality in the intervention phase ($r = -0.25$), suggesting that a certain number of mental training sessions (one-minute on-the-bench sessions) in which lower heart rate was manifested were associated with subsequent decreased performance (in the following at-bat). This finding points to the need to closely monitor this player's "Lock-in" session and reduce the occurrence of longer periods of low heart rate (possible state of insufficient arousal or physiological reactivity. Engaging in the "Lock-in" HRD protocol as precisely as possible should prevent lower HR from predominating and eventually carrying over into the batting box.

Athlete's Profile: Subliminal Attention: MEDIUM; Subliminal Reactivity: LOW; Subliminal Coping HIGH

Player S

Intervention Efficiency: −10.5
Pre-Intervention (CM → QAB): −0.074
Intervention (CM → QAB): 0.184
Differential (pre-post): 0.11
Pre-Intervention (CM → SUC): −0.086
Intervention (CM → SUC): 0.049
Differential (CM → SUC pre-post: 0.135
Player Criticality and HRV Response and Outcome Association Findings (Micro-level):
Intervention: L : H and CM 0.288

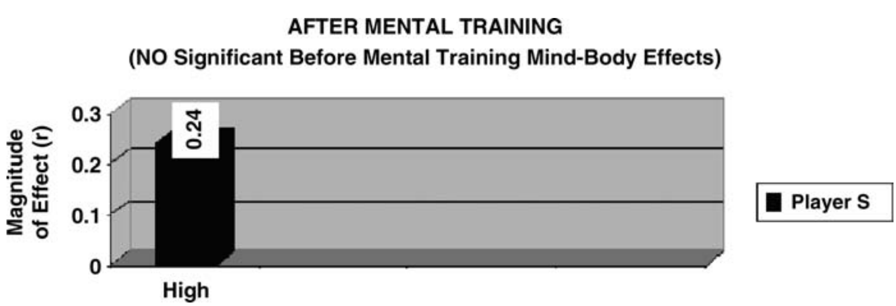


Figure 11.28 Intervention HRV and performance.

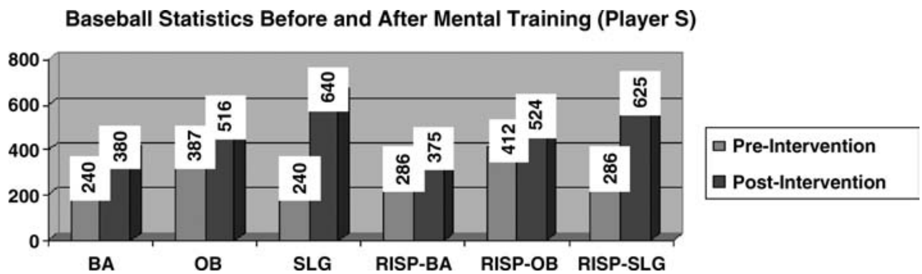


Figure 11.29 Pre vs. post statistical performance differences.

This player is another power hitter whose performance was subpar in the first half of the season. However, he made strong gains in the intervention phase especially in mental toughness categories. His improvement could be attributed in part to the one-minute "Lock-in" HRD protocol in which High frequency HRV activity contributed about 6% of the variance in batting success. High frequency activity is associated with parasympathetic nervous system predominance that is hypothesized to occur on an enhanced level during the exhale cycle of this protocol. Whenever an attempt is made to entrain (using biofeedback) a psychophysiological response that is temporally isolated or removed from an actual task or performance condition (e.g. when actually batting) any evidence of a response having an impact is crucial to establishing a procedure's potency or validity (criterion-referenced validity; predictive validity of a biofeedback protocol). In this player, as with the previous and subsequent case studies, regression analyses provide practitioners and researchers important insight regarding the effect, non-effect or negative effect of an intervention as expressed in a variance explained. This important methodological component of the CP attempts to bring accountability to the assessment and intervention process and establish intervention efficacy on the basis of the extent a baseline or induced psychophysiological response is associated with macro and micro level statistical outcome measures of a sport.

Relative to Criticality, in Player S, the Low frequency, High frequency ratio (L:H) an HRV measure that can easily be manipulated through prescribed breathing was associated with increasing criticality ($r = 0.288$; ca. 8% of the variance). This player also had an "Athlete's Profile" on the cusp of being the most performance facilitative and as expected he performed well under critical moments pressure conditions. Like Player "J" he encountered more of these in the second portion of the season (higher level criticality).

Athlete's Profile: Subliminal Attention: MEDIUM; Subliminal Reactivity: LOW; Subliminal Coping HIGH

Player G

Intervention Efficiency: 29.7
Pre-Intervention (CM → QAB): 0.13
Intervention (CM → QAB): 0.09
Differential (pre-post): −0.04
Pre-Intervention (CM → SUC): −0.063
Intervention (CM → SUC): 0.041
Differential (CM → SUC pre-post: 0.078
Player Criticality and HRV Response and Outcome Association Findings (Micro-level): Pre-Intervention: CM and HRV 0.292; CM and LF −0.278

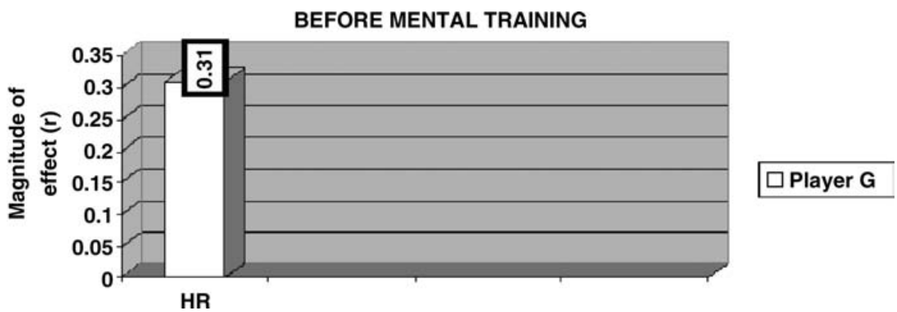


Figure 11.30 Pre-intervention HRV and performance.

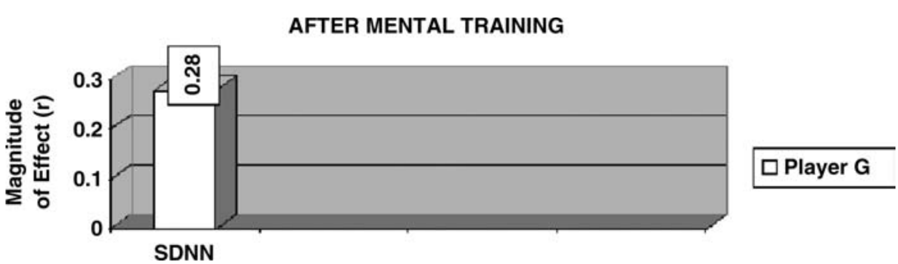


Figure 11.31 Intervention HRV and performance.

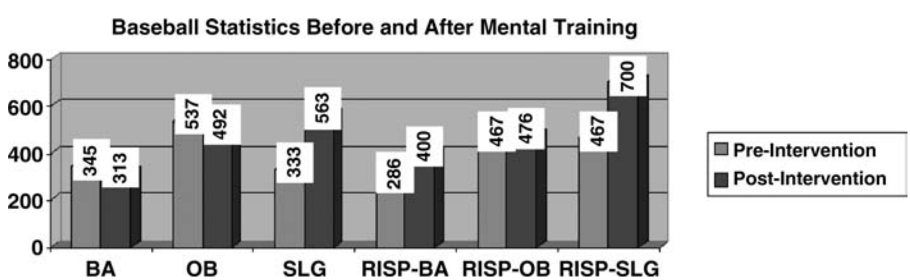


Figure 11.32 Pre vs. post statistical performance differences.

This is a very talented and physically imposing player; however, he has a more vulnerable "Athlete's Profile" being in the high range for subliminal attention and high-medium range for subliminal reactivity and low range for the performance protective subliminal coping measure. As such, Player G is likely to be more psychologically vulnerable during critical moments of competition. HR stood out as being performance facilitative in the pre-intervention phase accounting for 9% of the variance in batting success. This player made significant gains in slugging performance both in routine and RISP-critical moments situations in the intervention phase. The fact that SDNN emerged as being associated with batting success in the intervention phase suggests that Player G had a higher degree of intervention efficiency (which he did, +29.7) since SDNN is expected to be the most responsive or likely to change as a function of the "Lock-in" HRD HRV protocol. Relative to Criticality, HR was positively associated with increasing level of CM ($r = 0.292$; ca. 9% of the variance) and Low frequency was negatively associated with increasing level of CM ($r = -0.278$; ca. 7% of the variance). This can be interpreted similarly as previously, whereby, those "Lock-in" HRD trials (intervention sessions) that generated greater heart rate (beats-per-minute; bpm) being linked to better critical performance and those that generated more Low frequency activity being associated with poorer critical moment performance. Again, such discrepancies or possible inconsistencies in HRV responses in relationship to outcome may reflect differences in intervention efficiency across mental training sessions.

Athlete's Profile: Subliminal Attention: HIGH; Subliminal Reactivity: MEDIUM/HIGH; Subliminal Coping LOW

Player MC

Intervention Efficiency: −2.1
Pre-Intervention (CM → QAB): 0.079
Intervention (CM → QAB): 0.218
Differential (pre-post): 0.139
Pre-Intervention (CM → SUC): 0.248
Intervention (CM → SUC): 0.030
Differential (CM → SUC pre-post: −0.218
Player Criticality and HRV Response and Outcome Association Findings (Micro-level):
Intervention: CM and HR −0.459

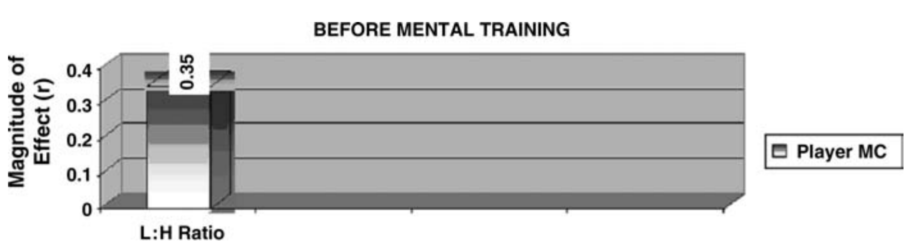


Figure 11.33 Pre-intervention HRV and performance.

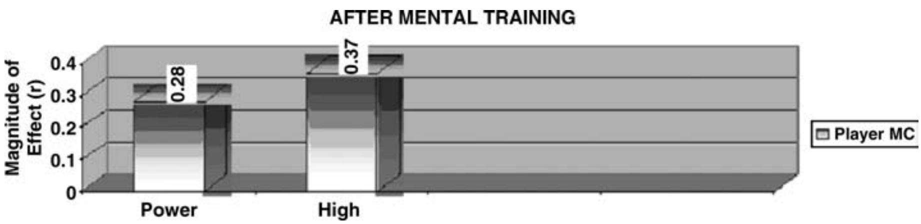


Figure 11.34 Intervention HRV and performance.

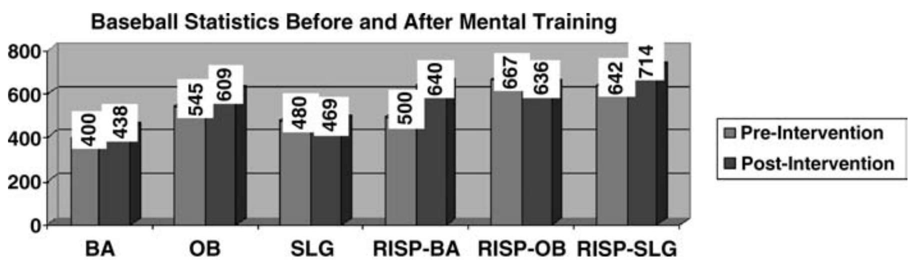


Figure 11.35 Pre vs. post statistical performance differences.

This player is a very talented player who is also on the cusp of having the one of the two best Athlete's Profiles. His pre-mental training statistics were very good and he performed even better during the intervention phase, especially when it came to "mental toughness" statistics. His pre-intervention L:H ratio and the fact that it was positively correlated with batting success (explaining 12% of the variance in batting success that could be attributed to L: H ratio HRV) is consistent with his Athlete's Profile PHO constellation. In the intervention phase, Power (sum of all frequencies) and High frequency activity emerged as being performance facilitative with this latter parasympathetic predominant response explaining about 14% of the variance in batting success. Relative to Criticality, in the intervention phase, greater HR was associated with poor CM Performance, suggesting that those intervention sessions in which higher HR predominated (associated with less HRV (more HRV should occur in the "Lock-in" HRD HRV protocol) resulted in similar higher HR responses as when batting and subsequent poorer performance, especially as level of criticality increased).

Athlete's Profile: Subliminal Attention: HIGH; Subliminal Reactivity: LOW; Subliminal Coping MEDIUM

Player JV

Intervention Efficiency: +24.8
Pre-Intervention (CM → QAB): 0.162
Intervention (CM → QAB): 0.024

Differential (pre-post): −0.067
Pre-Intervention (CM → SUC): 0.165
Intervention (CM → SUC): 0.035
Differential (CM → SUC pre-post: −0.13
Player Criticality and HRV Response and Outcome Association Findings (Micro-level):
No CM and HRV relationships pre or post

Figure 11.36 Pre-intervention HRV and performance.

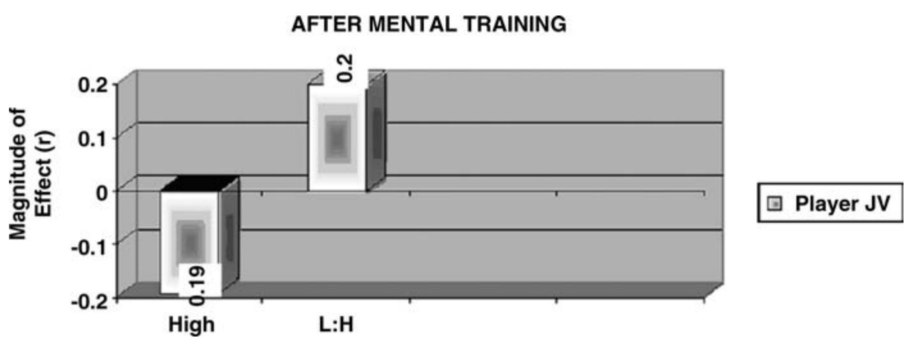


Figure 11.37 Intervention HRV and performance.

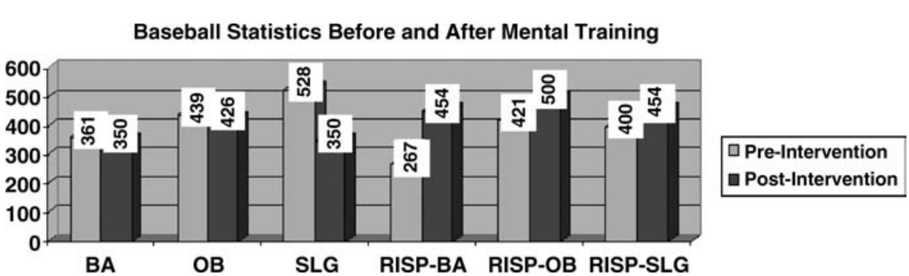


Figure 11.38 Pre vs. post statistical performance.

Although this player's pre-intervention statistics were higher than those during the intervention phase the differences were not statistically significant. However, importantly, this player's "mental toughness" statistics improved across the board which suggests that the intervention impacted macro-level pressure performance positively. In terms of HRV changes at baseline Player JV's L:H ratio was associated with batting success, explaining about 12% of the variance in performance that could be attributed to his baseline IZOF. By contrast, in the intervention phase High frequency HRV activity emerged as a performance hindering measure ($r = -0.19$), whereas, the L:H ratio maintained its performance facilitative effect, albeit to a lesser extent (4% of the variancein batting success could be attributed to the intervention generated L:H frequency). Such a pre-post discrepancy can be linked to a reduced intervention efficiency rating (however, this was not the case as JV had a high rating). It is also possible that in well-functioning athletes (positive baseline psychophysiological measures/performance facilitative HRV) with an ideal or positive Athlete's Profile PHO constellation, an intervention may not be necessary and can actually change a natural "Zone" state that positively predisposed athletes have developed, one that manifests itself during competition, into a less performance facilitative state. Relative to Criticality and HRV, no relationships emerged in this player.

Athlete's Profile: Subliminal Attention: MEDIUM; Subliminal Reactivity: LOW; Subliminal Coping HIGH

Summary: Critical Issues in Sport Psychophysiology and Biofeedback

This chapter has not only intended to present components of a validated athlete assessment and intervention protocol along with team and individual case-study findings, but also to highlight important issues that have emerged pertaining to high evidentiary applied sport psychology and biofeedback (or lack thereof) that all practitioners need to be cognizant of, including the following.

1. Assessments and interventions are often administered in an ad hoc manner devoid of any underlying construct validity and coherent and integrative conceptual context.

   This point of critique was addressed within a multidimensional conceptual framework that integrated relevant research from the domains or personality, behavior, neuropsychology/applied neuroscience, applied psychophysiology and biofeedback in the context of testable hypotheses to arrive at high levels of predictive validity the ultimate benchmark for determining the strength of a relationship between predictor and criterion measures.
2. The need for ecological data that is procured during actual competition. It is no longer tenable to carry out biofeedback sessions in the office only and

without prior additional real-world psychophysiological monitoring and then merely assume that a protocol will work or generalize to the playing field, or believe an intervention works on the basis of fallacious notions like practitioner and athlete beliefs about efficacy (see Dual Placebo Effect, Carlstedt, 2010) or cursory outcome measures like winning a match after a biofeedback session.

This chapter presented a comprehensive applied psychophysiological and biofeedback paradigm that was designed to be applied during real competition (official games). Such an ecological protocol is crucial to establishing dose-response and temporal parameters and the efficacy of an intervention (see (3)).

3. Athletes are taught visualization techniques, cognitive strategies, biofeedback and other methods in the context of the intake or first session (often in group settings) and then sent on their way under the assumption that: (a) a client has learned a mental training (MT) technique and is capable of practicing it; (b) the temporal properties of a MT technique are such that they can be applied at any time and then work later or on command; and (c) MT will generalize to the real word of competition. Most MT techniques are designed to "relax" an athlete; yet *no* practitioner (other than myself and ABSP trained and certified practitioners) could be located who actually monitored athletes during official competition (an integral component of the American Board of Sport Psychology/Carlstedt Protocol athlete assessment and intervention protocol) to determine: (i) whether an athlete is/was engaging in the prescribed MT technique; (ii) whether and what sort of psychophysiological responses are/were associated with engaging in MT prior to and during actual competition; and importantly (iii) whether engaging in a MT training technique really improves/improved performance, and if so, to what extent this assumption of MT-efficacy can/could be validated (on the basis of objective statistical outcome measures that are accrued longitudinally at the intra-individual level)?

Issue (3) is perhaps the most critical issue in applied sport psychology and biofeedback, since establishing dose-response, temporal and criterion-referenced relationships between predictor and criterion measures are absolutely vital to efficacy testing and ultimately determining the amount of variance explained in an outcome measure that can be attributed to an intervention. The above findings clearly reveal how complex intervention efficacy can be. On one hand a macro-outcome measure may suggest that mental training made a huge impact, especially at the team level (group level), yet when individual players are analyzed in the context of micro-outcome measures like critical moments the seemingly clear association between an intervention and outcome becomes more muddled.

Conclusions

1. Construct validity: a strong conceptual framework will increase the likelihood that higher levels of variance explained in an outcome measure can be attained and directly linked to brain-mind-body-motor processes that are hypothesized to mediate peak performance.
2. The Individual Zone of Optimum Functioning (IZOF) model, one of the dominant models of peak performance was supported in this study. Individual HRV response profiles emerged as a function of baseline, intervention and criticality conditions.
3. Interventions don't always work: while Macro-global statistics such as pre versus intervention batting average may suggest that performance gains resulted from mental training an in-depth analysis of multiple micro-outcome measures main reveal differential performance gains or decrements in the same player. Consequently, an evidence or interpretive hierarchy should be constructed to evaluate the impact of an intervention in terms of the magnitude of association between an intervention and most important micro-level outcome measures of a specific sport; usually level 4 or 5 Critical Moment events during competition.
4. Intervention efficiency should be assessed to determine to what extent an athlete is engaging in a prescribed intervention (e.g. HRD of the "Lock-in" protocol) especially when there is a temporal lag between when an intervention is practiced (entrained) and applied when it counts (e.g. when actually batting).

Overview

The presented protocol is proprietary and copyrighted, not to prevent the dissemination of its procedures and methodologies but to control its use or prevent the misuse of a protocol that has been validated at great expense over the last fifteen years. Practitioners are invited to become trained in the CP protocol and participate in an ongoing project to better assess athlete functioning during competition and document the efficacy interventions. The goal of the American Board of Sport Psychology is to develop an international cadre of practitioners who are seriously interested in engaging in a systematized, high evidentiary approach to applied sport psychology, one that eschews simplistic solutions, guruism, the misuse of technology and biofeedback, one that is dedicated to valid and reliable procedures, one in which information and accountability reign and athletes, coaches and organizations are provided with individualized data on performance even if it reveals negative associations between an intervention and subsequent performance. For more information on the American Board of Sport Psychology please contact rcarlstedt@americanboardofsportpsychology.org or visit www.americanboardofsportpsychology.org.

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12

Case 10 – Performance Anxiety, Biofeedback and the Pianist

Wind Instrument Players are not the only Musicians Affected by Breathing

Tom D. Kennedy and W. Alex Edmonds

Introduction

According to the DSM-IV-TR, a specific phobia is distinguished by a marked and persistent fear that is excessive or unreasonable, cued by the presence or anticipation of a specific situation. With the case of "Eli" (his name was changed to ensure anonymity) the "situation" was performing in public (specifically playing piano in public). When Eli was exposed to this situation it provoked an immediate anxiety response (i.e. a panic attack bound by the situation). Eli acknowledged that this fear was excessive and unreasonable, however he felt powerless to change. Eli would easily meet the criteria necessary to meet the diagnosis for 300.29 (specific phobia, formerly known as simple phobia) as per the DSM-IV-TR. The type of anxiety experienced by Eli is commonly referred to as performance anxiety or "stage fright." Small amounts of anxiety or stress is known to enhance aspects of performance (e.g. increased concentration), however, extreme amounts of anxiety, as experienced by Eli, can lead to diminished coordination as physiological processes (e.g. heart rate, muscle tension and breathing) deteriorate.

This pattern is a somewhat simplified explanation of a very complex phenomenon; nevertheless it provides a good starting point for conceptualizing the interplay between factors of anxiety and performance. The relationship between these factors, known as an Inverted-U performance curve, seen in Figure 12.1, is well known to many performers; in fact one study found that 59% of musicians suffer from anxiety that negatively affects their performance (Stephenson and Quarrier, 2005).

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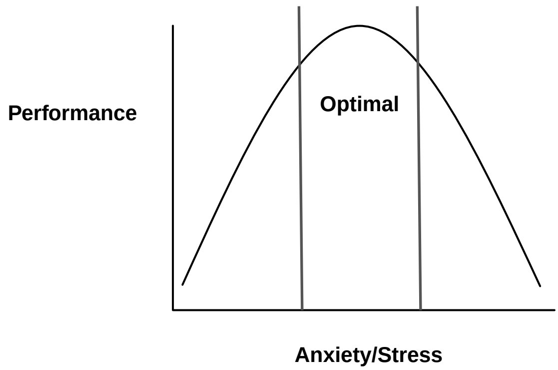

Figure 12.1 Inverted-U performance curve.

In the case of Eli, his anxiety became so severe, that he literally froze up and was unable to continue; thus he chose to avoid public performances altogether. The good news is that various interventions including relaxation-breathing training (Su *et al.*, 2010), and progressive muscle relaxation (Kim, 2008) can positively impact the deleterious effects of anxiety associated with musicians in general, and pianists specifically.

Background Information of Client

Eli was a 12-year-old male piano player who came to us while he was preparing for a piano recital. Eli was born in Colombia, but had been living in the United States since he was 18 months old. At the time, he lived with his mother, and her boyfriend. Eli's mother scheduled the appointment with us due to Eli's apparent high levels of stress and anxiety; specifically, anxiety that she felt was keeping him from performing in public. According to Eli's mother, "Eli is a gifted piano player," who enjoyed playing "more than anything else in his life." In addition, Eli's piano teacher thought that Eli could become a professional pianist one day. However, Eli had consistently turned down opportunities to demonstrate his talents, because of his "fear of playing in front of people."

Description of the Presenting Problem

Eli appeared to be a very intelligent and intuitive boy. He was in a Gifted Program and, along with piano, he performed exceptionally well in math and writing. At home Eli was often confrontational with his mother and has had frequent angry outbursts, which included raising his voice, running and slamming doors. He described himself as a perfectionist, and got upset when he failed to receive the top scores on academic tests in his class.

Eli stated that "he loves playing piano" and wanted desperately to be able to "play in front of others." However, when he was asked by his piano instructor to perform at various events he usually avoided the question or refused outright. He felt an intense fear when he even imagined himself performing in front of others. Eli discussed two specific attempts he had made to play in front of a group of people. The first one he was so "stressed out" that he froze up and excused himself from the room. Another performance he was scheduled to play, he "pulled out of" the night before. Eli was aware that his fears were not rational; however, he had "no idea" how he could "get over" them in order to pursue his dream of playing piano professionally.

Assessment and Diagnosis

As part of the assessment and diagnosis, we decided to employ a design for which we coined the term "sequential case study single-case design" (Edmonds and Kennedy, 2012). The title is a mouthfull, but the general idea is to apply a mixed methods approach by including an introductory phase of collecting primarily qualitative data (with quantitative data embedded) through a case study design, and then, based on the findings, follow it up with a single-case A-B design. For the initial step, our focus was on developing a narrative and revealing the phenomenon of Eli's underlying issues based on an in-depth analysis. Issues related to experimental control and internal validity are nonfactors with this approach. We do recognize that one cannot infer causation from case studies and that the results cannot be generalized; however, the findings can provide rich insight about a phenomenon and serve as support for theories and the generation of hypotheses.

Generally, the sequential case study single-case design is considered an exploratory approach and the emphasis is both on qualitative (QUAL) and quantitative (QUAN) methods sequentially delivered. The general steps began with the utilization of the case-study approach to detail and reveal the intricate cognitive and behavioral patterns associated with Eli's performance anxiety issues. Information gathered during the case study was then applied to the biofeedback intervention implemented, and the effects were then assessed through the use of an A-B design.

Specifically, for the case study design aspect, a phenomenological approach was applied to guide the QUAL phase of this investigation. This approach was appropriate, as we were interested in exploring the meaning, composition, and core of a lived experience of the specific phenomenon. In this case, that specific phenomenon was "performance anxiety" experienced by Eli while playing the piano for others. The approach was chosen because it is best suited in providing the framework to investigate the phenomenon (i.e. performance anxiety) within its real-world context; since the boundaries between phenomenon and context were not clearly evident.

Phenomenological interviews were conducted with Eli, his mother, and his piano instructor. The interviews included open-ended questions to build upon and explore Eli's past and present. Each participant was able to reconstruct their own experiences as they related to Eli. We then viewed these individual stories collectively in an attempt to understand the meaning behind their shared experiences. After each interview, we shared the transcript with the interviewee and requested that they were checked for accuracy, making additions and deletions to further clarify their experiences and perspectives. Follow-up interviews were conducted with Eli, during the initial sessions. We used Wolcott's (1994) approach of description, analysis, and interpretation as a method for making sense of interview data. The constant comparison method of reflecting and exploring the data allowed emerging patterns to collectively come into focus.

During the interview phase, rapport was established, facilitated by the use of semi-structured interviews and the dialogue that ensued while Eli completed a battery of quantitative measures to assess his level of functioning. The purpose of these measures were threefold: (a) it allowed Eli to gain greater insight into his presenting problems; (b) it served as a baseline to compare future changes upon completion of the intervention; and (c) it served as a guide for constructing the appropriate biofeedback intervention. Based on the qualitative thematic analysis, there were several recurrent patterns which emerged. Specifically, these were the issues of confidence, stress and anxiety, which then necessitated the collection of subsequent quantitative data.

First, the Music Performance Anxiety Inventory for Adolescents (MPAI-A) was administered to assess the somatic, cognitive, and behavioral components of Music Performance Anxiety (MPA; Osborne and Kenny, 2005). Eli had to respond to questions related to somatic (e.g. "Before I perform, I get butterflies in my stomach"), behavioral (e.g. "I would rather play on my own than in front of other people"), and cognitive (e.g. "I often worry about my ability to perform") aspects of MPA (see Table 12.1). Eli scored a 76 on the MPAI-A indicating an extremely high level of musical-performance anxiety.

Next, to globally measure how the degree that life situations (based upon the interview of Eli's mother, we felt this to be an important factor) were impacting Eli, the Perceived Stress Scale (PSS; Cohen and Williamson, 1988) was administered (see Table 12.2). This scale is a good measure of physiological indices of stress, Eli responded to questions related to how he appraised life situations as stressful, unpredictable, or uncontrollable. Eli scored a 28 on the PSS, more than double the average score, suggesting that he felt his life is rather unpredictable and uncontrollable.

Based on the information from these measures and the semi-structured interview, we were able to detail his background information and better flesh out his presenting problem. After these initial sessions, it was clear that a major reason Eli was unable to perform publicly was due to the fact that he was having problems, first, utilizing effective coping strategies when faced with general stress, and second, regulating his performance anxiety when faced with the specific stress of playing piano in front of others. This was further confirmed speaking to his mother and his piano instructor.

At that point, it was important to determine the specifics as to the extent of his feelings of anxiety and how this was affecting his confidence. When asked, his response was that he was extremely nervous during competition and not as much during practice. We wanted to determine how Eli's self-confidence was influencing the quality of his performance, therefore we implemented Bandura's (1997) model

Table 12.1 Music Performance Anxiety Inventory for Adolescents (MPAI-A).

Please think about music in general and your major instrument and answer the questions by circling the number, which describes how you feel.

	None of the time		*About half the time*			*All of the time*	
1. Before I perform, I get butterflies in my stomach	0	1	2	3	4	5	6
2. I often worry about my ability to perform	0	1	2	3	4	5	6
3. I would rather play on my own, than in front of other people	0	1	2	3	4	5	6
4. Before I perform, I tremble or shake	0	1	2	3	4	5	6
5. When I perform in front of an audience, I am afraid of making mistakes	0	1	2	3	4	5	6
6. When I perform in front of an audience, my heart beats vary	0	1	2	3	4	5	6
7. When I perform in front of an audience, I find it hard to concentrate on my music	0	1	2	3	4	5	6
8. If I make a mistake during a performance, I usually panic	0	1	2	3	4	5	6
9. When I perform in front of an audience I get sweaty hands	0	1	2	3	4	5	6
10. When I finish performing, I usually feel happy with my performance	0	1	2	3	4	5	6
11. I try to avoid playing on my own at a school concert	0	1	2	3	4	5	6
12. Just before I perform, I feel nervous	0	1	2	3	4	5	6
13. I worry that my parents or teacher might not like my performance	0	1	2	3	4	5	6
14. I would rather play in a group or ensemble, than on my own	0	1	2	3	4	5	6
15. My muscles feel tense when I perform	0	1	2	3	4	5	6

Source: Osborne, M.S. and Kenny, D.T. (2005) Development and validation of a music performance anxiety inventory for gifted adolescent musicians. *Journal of Anxiety Disorders*, 19, 725–751.

of self-efficacy. Bandura defined perceived self-efficacy as "the beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). Utilizing the guidelines set forth for constructing self-efficacy scales, we devised a scale to determine the level of self-efficacy Eli perceived performing alone (condition 1), performing for his instructor (condition 2), performing for his family (condition 3), performing for his friends (condition 4),

Table 12.2 Perceived Stress Scale (PSS).

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?	0 1 2 3 4
2. In the last month, how often have you felt that you were unable to control the important things in your life?	0 1 2 3 4
3. In the last month, how often have you felt nervous and "stressed"?	0 1 2 3 4
4. In the last month, how often have you felt confident about your ability to handle your personal problems?	0 1 2 3 4
5. In the last month, how often have you felt that things were going your way?	0 1 2 3 4
6. In the last month, how often have you found that you could not cope with all the things that you had to do?	0 1 2 3 4
7. In the last month, how often have you been able to control irritations in your life?	0 1 2 3 4
8. In the last month, how often have you felt that you were on top of things?	0 1 2 3 4
9. In the last month, how often have you been angered because of things that were outside of your control?	0 1 2 3 4
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0 1 2 3 4

Source: Cohen, S. and Williamson, G. (1988) Perceived stress in a probability sample of the United States, in *The Social Psychology of Health: Claremont Symposium on Applied Social Psychology* (eds S. Spacacam and S. Oskamp), Sage, Newbury Park, CA. Reproduced with permission from Sage Publications

performing for an audience (condition 5). The strength of self-efficacy was assessed by asking Eli to rate the degree to which he felt confident in his ability to execute in one of these five conditions (e.g. "How confident are you in your ability to perform in front of your family?"). Response options were based on a scale that ranged from 0 (*not confident at all*) to 100 (*extremely confident*). The same questions were asked for all five conditions.

As seen in Figure 12.2, Eli felt extremely confident in the first two conditions but his efficacy beliefs tapered off dramatically through condition 3–5. Self-efficacy is known to be influenced by various sources of efficacy information. Therefore, the next step was to address the sources of efficacy. The most influential factor that is known to influence self-efficacy is mastery experience or prior performance, but secondary to that are physiological and affective states (Bandura, 1997). We can't directly change his mastery experiences or prior performances, but we can manipulate his affective states and his ability to regulate his emotions.

Eli already expressed to us (through his responses to interview questions, and extremely elevated scores on the somatic, behavioral, and cognitive portions of the MPAI-A) that he was overly anxious at times during practice and unable to function

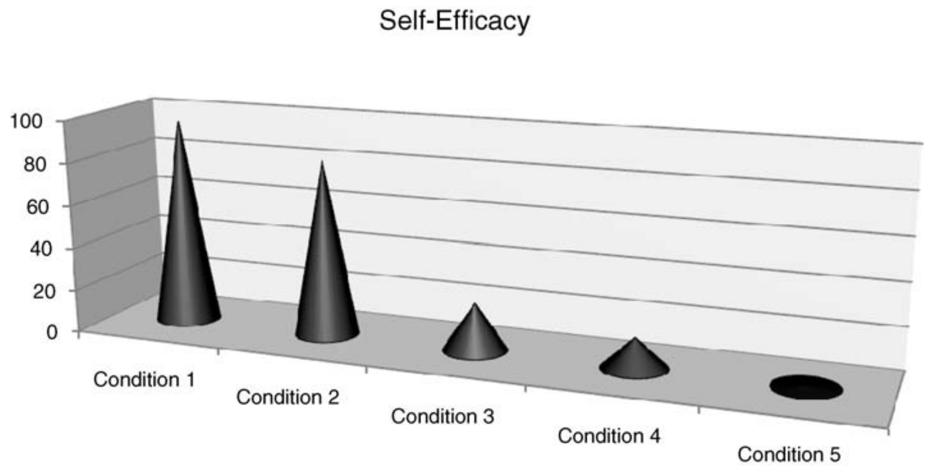

Figure 12.2 Self-efficacy across five conditions.

during public performances. These symptoms were further exacerbated by the impact of general life stressors (nonperformance related), as indicated by his high score on the PSS. At this point, we needed to get a better grasp on his thoughts and perceptions of physical anxiety related to performance. To further assess Eli's cognitive (i.e. thoughts) and somatic (i.e. bodily reactions) levels of anxiety, we administered the revised version of the Competitive State Anxiety Inventory-2 (CSAI-2R; Cox, Martens, and Russell, 2003). Yoshie *et al.* (2009) demonstrated that the CSAI-2R could reliably predict the anxiety-performance relationship with pianists just as well as it does for athletes. Therefore, we felt the scale would be relevant to use with Eli. We were also interested in the cognitive mediational processes in the context of a music performance, which can be considered a part of the scale through the assessment of his overall self-efficacy (McCormick and McPherson, 2003). According to Martens *et al.* (1990), the scoring of the CSAI-2R is achieved in the following way: A person rates how they are feeling right now by circling one of the presented answers. The four-presented answers include *not at all* (1), *somewhat* (2), *moderately so* (3), and *very much so* (4). The final scores for each subscale will range from 9 to 36, with 9 indicating low anxiety/confidence and 36 indicating high anxiety/confidence.

As shown in Figure 12.3, Eli was experiencing elevated levels of somatic and cognitive anxiety, along with low self-confidence, associated with his piano performance. The heightened responses to anxiety would result in shaky hands, sweaty palms, stomach butterflies, muscular tension, and ultimately a preoccupation with his nervousness prior to his piano performances. The findings from this case-study assessment revealed the importance of developing a biofeedback-based intervention designed specifically for Eli so he could learn how to regulate his affective and cognitive states to improve his piano performance during recitals.

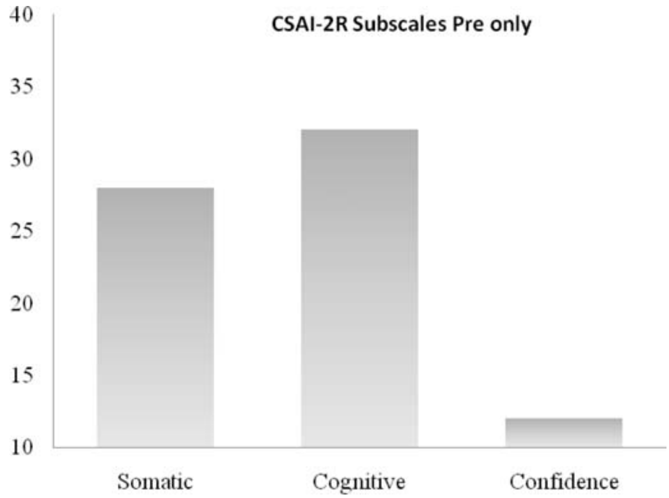

Figure 12.3 Scores on the CSAI-2R.

Intervention

Breathing techniques have been used for centuries to improve mental and physical well-being, as well as for spiritual growth, coping, and enlightenment. However, only recently has biofeedback (BFB) been paired with breathing strategies as a means for providing empirically-based evidence to support what we already know regarding the positive effects of focused breathing strategies. Respiration sinus arrhythmia (RSA) BFB has been shown to be a viable and effective method for improving psychophysiological states related to various performance contexts (i.e. the effectiveness of the BFB-assisted breathing therapies is evidenced through changes in cardiac variability known as heart rate variability (HRV)). Leher (2007) posited that, while breathing diaphragmatically, six breaths per minute is likely to provide therapeutic effects for all (i.e. breathing at six breaths per minute improved heart rate variability enough and most achieve resonance frequency or come very close). We felt this was a good starting point for our breathing intervention. However, within the general parameter that values resonance frequency at ~.1Hz or six breaths per minute, there are unlimited breathing patterns (or ratios) that can be applied. Based on preliminary findings from a recent study (Edmonds *et al.*, 2009), we wanted to allow Eli the opportunity to choose one of four breathing patterns (diaphragmatic breathing) which he felt most comfortable with while keeping all breathing rates at six breaths per minute. Therefore, we developed a breath-related BFB intervention by utilizing respiration and cardiovascular indices as a means to help Eli to learn how to self-regulate his emotional states and improve his performance on the piano. The treatment took place at Eli's home where he felt most comfortable. We were able to use a laptop computer and an additional monitor.

Our laptop computer was configured to utilize a dual-monitor setup and we equipped it with BioTrace+ Software® Advanced Physiological Monitoring and

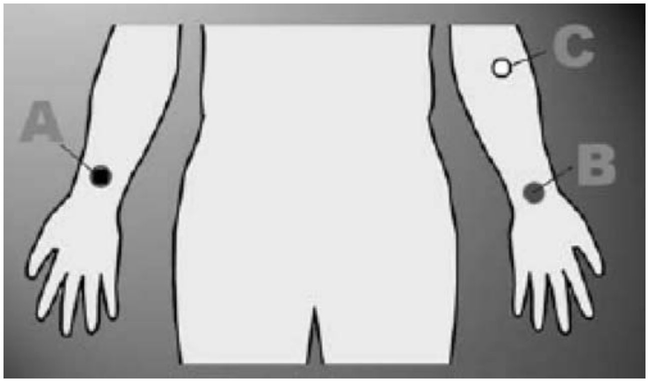

Figure 12.4 ECG sensor placement (A = Negative; B = Positive; C = Ground).

Feedback by Mind Media B.V. software (Version 2008a; US, Roermond-Herten, The Netherlands), which was used to manage the data collection. We used the portable NeXus-4™ wireless Bluetooth BFB system, which is ideal for field work and home visits.

Because our intervention was focused only on breathing strategies, we utilized the two sensors to monitor respiration and HRV. An abdominal strain gauge was used to measure respiratory activity. When connected, the strain gauge was applied snugly, yet comfortably, around the center Eli's abdominal region. We used an on-screen "Pacer" to assist and guide Eli to breathe at the desired rates. The pacer was configured for four primary settings that included "Inhale," and "Sustain" (pause at the top of inspiration), "Exhale," and "Pause" (pause at the bottom of the expiration) times. We utilized channels *A and B* on the NeXus-4 for the electrocardiography (ECG) and channel *D* for the respiration gauge. The BVP sensor connected to the finger was not a practical choice because it would interfere with Eli's ability to play the piano while connected. As seen in Figure 12.4, we used a simple lead II configuration, which included pre-gelled disposable silver/silver chloride snap sensors (electrode 4630) placed on the interior of both the left and right forearms, with a ground electrode on the Eli's nondominant forearm.

We arranged the BioTrace+ Software® to sample at a rate to provide a high-resolution signal (i.e. 1024 samples per second) to collect the following HRV measures:

1. the standard deviation of the normal beat-to-beat heart rate intervals in ms (SDNN);
2. the percentage of successive normal interbeat intervals which differ by 50 ms or more (pNN50);
3. the spectral analysis reveals the component rhythms that make up the overall rhythm of heart activity. The spectral analysis reveals HRV across three different frequency ranges: (a) high frequency (HF: 0.15–0.4 Hz), (b) low frequency (LF: 0.04–0.15 Hz), and (c) very low frequency (VLF: 0.003–0.04 Hz).

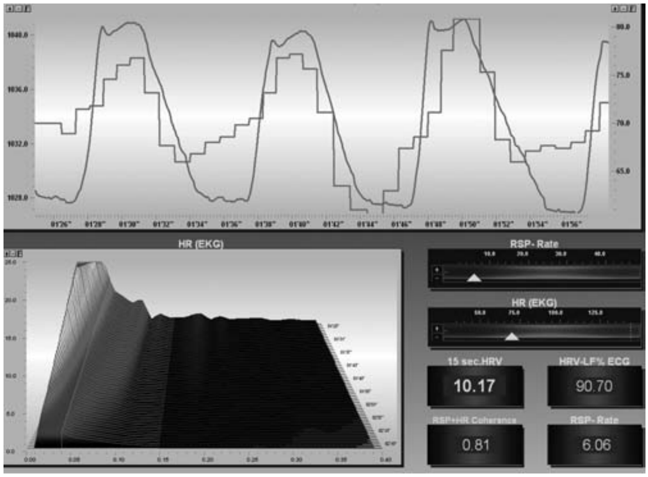

Figure 12.5 Practitioner BFB display.

Initially, we allowed Eli to go through an adaptation period (Arena and Schwartz, 2003). This included introducing him to the basics of BFB and the benefits from using such tools. Once we felt he was familiar and relaxed with the sensors and computer equipment, we proceeded with some practice breathing sessions. Eli was allowed to practice various breathing strategies until he felt comfortable with the arrangement. It is very important to note that Eli was guided to breathe diaphragmatically and was instructed not to breathe too deeply (i.e. if he took too many consecutive deep breathes he would start to feel the onset of hyperventilation). It took a very short period of time for Eli to become relaxed with the BFB screen. We utilized a dual-monitor setup that allowed us to view an extended display of all the modalities on one screen, while providing a very specific and limited view for Eli's screen. Eli's view included up to three parameters on the display: respiration patterns, and line pacer. As seen in Figure 12.5, our view included the respiration pattern, the spectral analysis, coherence score, breaths per minute, and the HR, which was displayed as a beat-to-beat cardiotachometer line display superimposed on the respiratory activity.

As previously mentioned, we utilized a version of the A–B single-case design. The "A" represented the introduction of the baseline period and then the "B" represented the introduction of the breathing condition. Overall, we introduced Eli to four different breathing strategies to determine which he felt most comfortable with. Therefore, in accordance to single-case methodology, we assigned each of the four conditions a letter of the alphabet reserving the letter "A" for the baseline condition. These were as follows: (B) 1:1 breathing ratio with a brief pause at the top and bottom of the breath, (C) 1:1 ratio with no pauses (i.e. 0.1 seconds were required between the inspiration and expiration to create the rolling breathing pattern), (D) 1:2 breathing ratio with no pauses, and (E) 1:2 breathing ratio with a pause at the top and bottom of each breath. The respiration rates for each of the four conditions were approximately 10 cycles per minute (i.e. six breaths per minute).

Table 12.3 Pacer settings times in milliseconds for patterns B, C, D, and E.

	Type of breathing pattern			
Direction of respiration	*B* 1:1 ratio with pause and sustain	*C* 1:1 Sinusoidal Pattern	*D* 1:2 ratio with no pause or sustain	*E* 1:2 ratio with a pause and sustain
Inspiration	3750	4990	3300	2500
Sustain	1250	10	0	1250
Expiration	3750	4990	6600	5000
Pause	1250	10	0	1250

Note: All patterns equate to approximately 6 breaths per minute.

Table 12.3 details the specific times (in milliseconds) allotted for each parameter setting in the electronic pacer for each of the breathing conditions. Figure 12.6 illustrates the various breathing patterns when presented on the BFB screen. The BioTrace + Software® included a computerized pacer that accounted for the 4 different settings (i.e. inspiration, sustain, expiration, and pause times).

Eli was then guided through the various breathing patterns in accordance with A–B design (see Figure 12.7). We had him go through three trials; within each trial Eli was guided through a series of the four different breathing conditions. We asked Eli to direct his attention to the screen and instructed him to follow the orange line pacer with the blue line, which was derived from his own breaths. Again, he was instructed to breath with his tummy (diaphragmatically), and not too deeply. In fact, the depth (inspiration) of his breath was no different than any normal breath. This is an important aspect to breath-related interventions and to keep your client from feeling the effects of hyperventilation. Immediately following each condition Eli was asked to rate his perceptions of ease and comfort in relation to the type of breathing strategy. Specifically, he was asked to give his perceptions of each breathing condition and how it related to his thoughts of "Ease" and "Comfort" (e.g. "How easy was this breathing condition for you?" and "How comfortable was this breathing condition for you?"). The two questions were rated on a 10-point scale ranging from "not at all (1)" to "very much (10)."

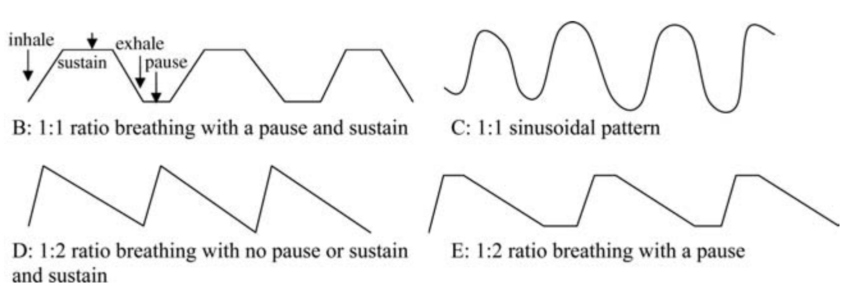

Figure 12.6 Diaphragmatic breathing patterns.

Baseline A	Pattern 1 B	Baseline A	Pattern 2 C	Baseline A	Pattern 3 D	Baseline A	Pattern 4 E

Figure 12.7 A-B-A-C-A-D-A-E design.

After the conclusion of the third trial Eli had consistently reported higher levels of ease and comfort with breathing pattern E, which was the 1:2 ratio breathing with a slight pause at the top of the inspiration and a pause at the bottom of the expiration. Through the application of the single-case A-B design we established that all breathing conditions produced high levels of low-frequency activity (which is in line with previous research), and determined that Eli felt most comfortable with breathing pattern E; therefore, we were able to commence with the breathing intervention.

Again, the goal of this intervention was to improve Eli's overall confidence (i.e. self-efficacy) with performing on the piano in front of spectators, and provide him the necessary tools to adequately cope with the anxiety levels he had associated with performance. We structured 10 sessions lasting roughly 30–45 minutes in length paired with an at-home training device so Eli could practice at his leisure. For the first four sessions we connected Eli to the BFB equipment and trained him during five-minute segments on how to breathe using pattern E. He was able to follow the line pacer on the screen to ensure he was breathing at the appropriate rate (∼6 breaths per minute) and frequency. It is important to note that Eli was consistently reminded to breathe in a calm and relaxed state. Clients often tend to breathe too deeply during focused breathing exercising, which can start the onset of hyperventilation. For the subsequent three sessions we connected Eli to the BFB and instructed him to breathe at the desired rate for five minutes and then had him play one song on the piano. Following the song, we had him reestablish his breathing pattern for the next five minutes and then had him play another song. After the seventh session we left Eli with a StressEraser™ (Helicor, New York) device and instructed him to practice at least once a day at his leisure using his preferred breathing pattern style. For the final three sessions we connected Eli to the BFB device, but did not allow him to view the screen. He was instructed to breathe at the appropriate rate and pattern at which he was trained prior to playing a song on the piano. This was an excellent exercise for Eli to practice breathing before performing his music without the assistance of BFB equipment, but at the same time allowing us the screen view to ensure he was breathing appropriately. And at the same time he was able to receive positive feedback from us while doing so. During the final sessions Eli demonstrated that he was able to breathe ∼6 breaths per minute using a 1:2 ratio with a brief pause and sustain at the top and bottom of the inspiration and expiration of the breath cycle without the assistance of BFB. Our feedback in the form of verbal persuasion was a great confidence boost for Eli in realizing that he was capable of controlling and regulating his performance anxiety and ultimately his performance on the piano.

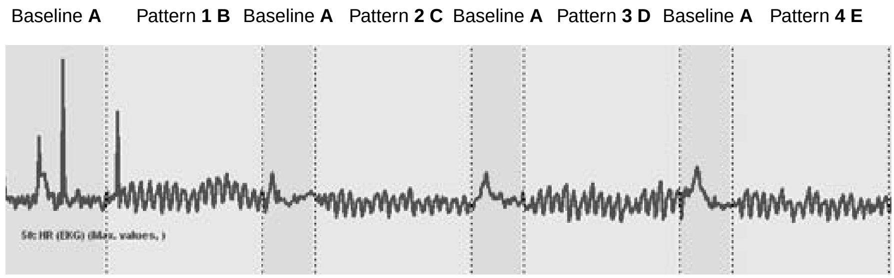

Figure 12.8 A-B-A-C-A-D-A-E design.

Outcomes and Discussion of Findings

As expected, all breathing conditions produced high levels of low-frequency activity with minimal activity in the high- and very low-frequency ranges (see Figure 12.8). For the exception of a few moments of artifact, the cardiotachometer display is smooth and even during each pattern. Notwithstanding, as seen in the results of the objective data, the magnitude of the differences between each condition were minimal. As we established in a previous study (Edmonds *et al.*, 2009), statistically speaking there is no difference between any combination of conditions – that is, while keeping breathing rate at ~.1 Hz, all of the breathing ratios produced optimal HR oscillations (with only nominal variations). This supports previous research that placed the emphasis on respiratory rates as opposed to patterns (Song and Lehrer, 2003; Vaschillo, Vaschillo, and Lehrer, 2006). However, since one condition (i.e. pattern) produced the most improved autonomic functioning, our past findings should be further explored.

As seen in Table 12.4, the descriptive statistics more appropriately demonstrate this outcome. Each breathing condition yielded over 80% activity in the low-frequency while minimizing activity in the high-frequency (< 11%) with marginal differences revealed between each condition. In addition, Eli produced relatively

Table 12.4 RV indices for each breathing pattern.

	Breathing pattern			
Indices	*B*	*C*	*D*	*E*
SDNN	76.05	75.01	72.94	75.20
pNN50	20.94	22.14	20.83	20.66
HF %	10.17	8.36	10.68	10.88
LF %	84.78	86.40	82.06	82.13

Note: SDNN = *SD* of the normal beat-to-beat heart rate intervals; pNN50 = percentage of successive normal interbeat intervals that differ by 50 ms; HF % = % of high frequency (0.15–0.4 Hz); LF % = % of low frequency (0.04–0.15 Hz).

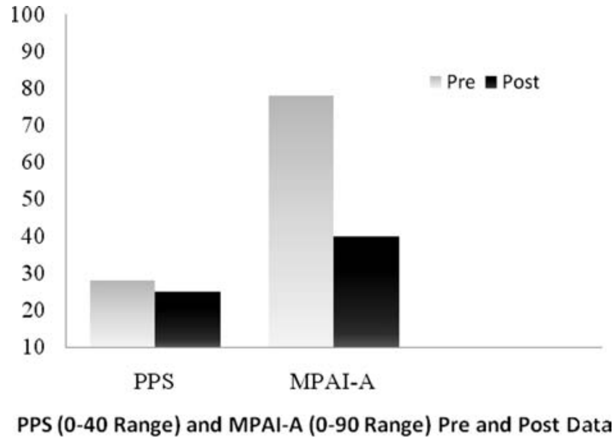

Figure 12.9 Pre and posttest scores of the PSS and the MPAI-A.

high SDNN values (> 72.0) and pNN50 values (> 20.5) for each of the four conditions.

Following the intervention we had Eli complete another round of the MPAI-A and the PSS (see Figure 12.9) as well as the CSAI-2R (see Figure 12.10). His scores on the MPAI-A were reduced almost by half. They still indicated a level of performance anxiety; however, Eli's scores now fall within a "manageable" range. Based on the CSAI-2R scores, Eli's perceptions of the different types of anxiety were substantially reduced after the completion of the breathing intervention. Of particular importance is the reduction of Eli's somatic anxiety. His sweaty palms and nervous jitters were the two things Eli reported as the most distracting. It also revealed that his levels of confidence were elevated. Eli told us that instead of worrying about his nervous stomach and slippery hands he can start his new breathing patterns before

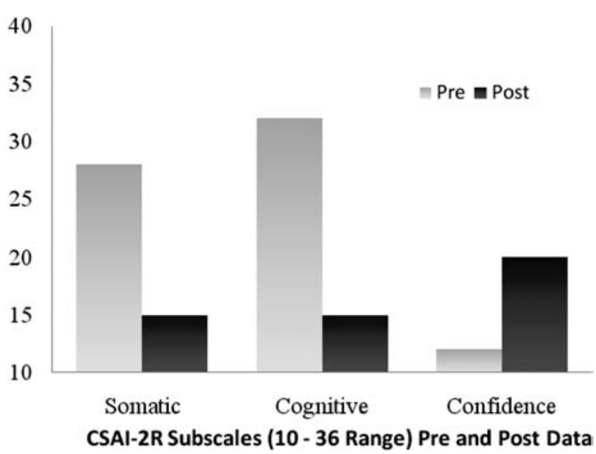

Figure 12.10 Pre and posttest scores of the CSAI-2R.

performing and he knows it will improve his overall performance. Interestingly, Eli's scores on the PSS remained elevated suggesting that even though he maintained some fairly high levels of general stress and anxiety, he has managed to significantly reduce his performance specific related anxiety. More importantly, Eli was able to perform twice (small venues) during the course of this treatment, and although it was not "perfect" it was amazing to see that he was able to complete two performances in front of an audience. We refer the reader to Papageorgi, Hallam, and Welch (2007) for more information regarding a theoretical framework for understanding the relationship between music and anxiety.

As we mentioned earlier, the goal of our intervention was to assist Eli with a powerful and effective coping strategy to deal with his performance anxiety. Eli's parents and piano instructor both noted positive improvements in Eli's attention to detail and focus while playing the piano. We believe it is important to note that Eli's improvements and accomplishments cannot be fully attributed to the BFB intervention. The BFB intervention, along with the interactions he had with us, served as a catalyst which helped improved his confidence and coping abilities related to his piano performance. The at-home practice and thought Eli put into this training was also an important contributor. We believe it is always important to encourage clients and stress the importance of commitment and dedication to an intervention as part of the overall practice it takes to being a better athlete or performing artist.

As previously mentioned, we revealed that Eli felt most comfortable with the 1:2 breath ratio with a brief pause and sustain (i.e. short inspiration and long expiration). Strauss-Blasche *et al.*'s (2000) demonstrated improved HRV measures during trials of short inspiration followed by long expirations, and although we did find improved HRV measures across all breathing patterns, there seems to be some merit to the idea that a 1:2 breathing ratio at six breaths per minute may allow for "optimal" HRV functioning. That is, there is a more complete acetylcholine metabolism with longer expiration than inspiration, which produces higher amplitudes of respiration sinus arrhythmia. This can be partially explained by the pronounced phasic increase in heart rate, which is linked to "fast" inspiration, but not related to the phasic deceleration during expiration. These physiological conditions may also explain the concept of *flow* and optimal functioning as noted in Manzano *et al.*'s (2010) research with piano players. Further research should be conducted to determine the link between optimal zones of functioning and physiological states.

As we noted in our previous study and in the case of Eli, it is important to consider the client or patient's comfort level with a specific breathing pattern (i.e. the within-cycle respiratory times) in association with the objective HRV analysis and, upon application, find the balance between the two (Hughes, 2008). Specifically, it is important to account for the individual or within-differences when attempting to effect change via psychophysiological mechanisms. This contention follows Malmo and Shagass's (1949) individual response-stereotypy, which states that individuals maintain idiosyncratic patterns of responding. Additionally, these considerations are also relevant aspects of patient adherence to treatment protocols, particularly when they are expected to participate in at-home training.

The current case tested a healthy subject; however, the viability of considering the inspiration and expiration ratios can be also very relevant for patients suffering from dysfunctional breathing such as hyperventilation syndrome, asthma, or chronic obstructive pulmonary disease. Varied ratio breathing may also be appropriate when applying HRV BFB and examining the baroreflex effects along with blood pressure in patients with fibromyalgia and other neuromuscular diseases. Patients suffering from clinical levels of depression or anxiety often receive treatment in multiple settings, and may be sensitive and respond positively to having the option to varied breathing ratios when receiving breathing interventions, which may improve treatment adherence (Dubovsky, 2005). The array of applications and diversity of populations warrants additional research and practitioners should always consider multidimensional approaches while factoring in the subjective and objective variances of their clients.

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13

Case 11 – The 400-meter Sprinter Who Ran Too Fast!

W. Alex Edmonds

Background Information of Client

The client was a male sprinter competing on a Division I collegiate track and field team. For the sake of anonymity I will use the alias "Charlie" to refer to my client. At the time I started to work with Charlie, he was a sophomore in college and had been in track and field since he was a freshman in high school. In high school, he ran the 200 and 400 meter (m) dashes, and often participated in the 4 × 400 m relay. In his senior year, Charlie placed fourth in the 400 m at the high school state championships and was recruited to run the 400 m in college, as this was the event he excelled in.

The 400 m dash is an anaerobic, or oxygen-deficient event, and considered to be one of the toughest single events in sport. The runner must engage in a grueling endurance sprint a distance that is more than four times the length of a football field. After racing 400 m, the human body has been pushed to its physical limits, leaving barely enough energy for the sprinter to walk him or herself off the track. The emphasis on Charlie's training was to build strength, power, and endurance.

Once in college, Charlie was faced with many adversities as he tried to adjust to the novel academic and social cultures. Additionally, the workout regimens were more intense than those to which he was accustomed. Requisites for all sprinters – lifting weights, running stadiums and hills, and more intense workouts on the track – were taking their mental and physical toll on him. Resultantly, he strained his hamstring during practice three different times during the course of his freshman season. The time he spent in rehab, and apprehension of pushing himself too hard in practice for fear of overextending

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his hamstring, kept him from competing in any actual track meets. As a result, he was able to chalk up his freshman season as a learning experience and adjustment period.

Eager to start training for his sophomore season Charlie started to experience anxiety and worry. As the official training season commenced, he found that his on track times were not much better than what he was running in high school. Subsequently, his confidence started to decrease as his feelings of anxiety and worry started to increase.

Description of the Presenting Problem

Charlie's running times in practice were not improving from the previous year and were not much improved from the times that he was running in high school. I asked him how he envisioned himself as a runner and he said he wants to run just like the cheetah does when chasing its prey. However, he said that his workouts were wearing him down and instead of feeling like a cheetah he felt more like a "retired race car with watered down gas in a rusty tank."

Charlie's workouts were portioned into speed, tempo, and strength-endurance running styles. For example, he would run 10×100 m dashes to work on speed, 6×300 m dashes to work on tempo, and stadium running to work on strength. These workouts would vary during the week. The coach would break up the 400 m dash into segments and he would individually run each segment in practice in preparation to run the entire race in competition. Charlie would do well in some of the segmented running but become sluggish in other aspects. His lack of effort did not go unnoticed by his coach.

The performance feedback that Charlie was getting from his coach was negatively affecting his confidence issues. He was being told that his segment times and average times during endurance training was lacking and if he didn't start to improve he may be considered to run a different event such as the 800 m, which didn't interest Charlie at all. He was getting increasingly anxious during practice and started to overcompensate when training. In other words, he would run too fast during his segmented running and prematurely burn himself out early; thus he would never finish his races strong.

For the first time in Charlie's college career, he competed in two invitational track meets that took place to start off the outdoor track and field season. Subsequently, he didn't qualify in the preliminary heats in either meet to advance to finals and potentially score points for the team. Charlie believed that this type of production did not please his coach and teammates. In addition, he understood that he would have to do much better because the competition would get stronger in the conference and national relays. Generally speaking, over-thinking and overly anxious states were hindering Charlie's ability to have optimal practices, which in turn was hurting his overall performance in the track meets. Charlie wanted to get the water and rust out the gas tank!

Assessment and Diagnosis

In the first sessions, it is important to focus on building trust and a rapport with the client. Therefore, in our initial meeting I used a series of open-ended questions to gain more insight into Charlie's issues and allowed him to do most of the speaking. Specifically, I utilized the Sport-Clinical Intake Protocol (SCIP; Taylor and Schneider, 1992). This formalized interviewing protocol allowed me to obtain information from Charlie in seven important areas: (a) presenting problem, (b) life and athletic history, (c) social support, (d) health status, (e) important life events, (f) changes prior to onset of the presenting problem, and (g) details of the problem.

Based on the information from the SCIP, I was able to detail his background information and get a general idea of his presenting problem. After the first meeting, it was clear that the reason Charlie's times were not improving was due to the fact that he was having problems first, adjusting to the social climate and, secondly, regulating his competitive anxiety. This was further confirmed in watching some of his past races on video and in conjunction with testimony from his coach. At that point, it was important to determine the specifics as to the extent of his feelings of anxiety and how this was affecting his confidence. When asked, his response was that he was extremely nervous during competition and during practice and that he would "overrun" during certain aspects of the race, thusly burning himself out and finishing poorly.

Before any further deductions or decisions were made about how to approach Charlie's issues, it was important to understand his personal needs in relation to the sport as well as to the sport's demands. Therefore, Taylor's (1995) conceptual model for integrating athletes' psychological needs and physical demands was considered when determining how to approach Charlie's issues. For the typical collegiate male athlete, the 400 m lasts roughly anywhere from 43 to 51 seconds. The demands are intense and require a balance between sprinting and endurance performance. To perform it successfully, the race must be strategically broken into segments and run accordingly. There is little room for error. Sprinting involves a combination of fine and gross motor skills from start to finish and is completely an anaerobic activity. The difference between competitors' times can be as little as 0.01 seconds; therefore, it is crucial that the athlete performs at his or her optimal level of intensity and arousal. However, if a sprinter experiences over-arousal, or under-arousal, then it is likely the racer will experience performance decrements as illustrated in the "inverted-U hypothesis" that displays the relationship between arousal and performance (Yerkes and Dodson, 1908; see also Tenenbaum, Edmonds, and Eccles, 2008). More specifically, performance improves as arousal level increases, but only to a certain extent, then performance starts to decline as arousal continues to elevate. Next, it is vital that the sprinter is focused and able to concentrate, specifically, while in the blocks waiting for the gunshot that signals the start of the race. In reference to Nideffer's (1976) model of attentional focus, a 400 m sprinter must maintain a narrow and internal focus.

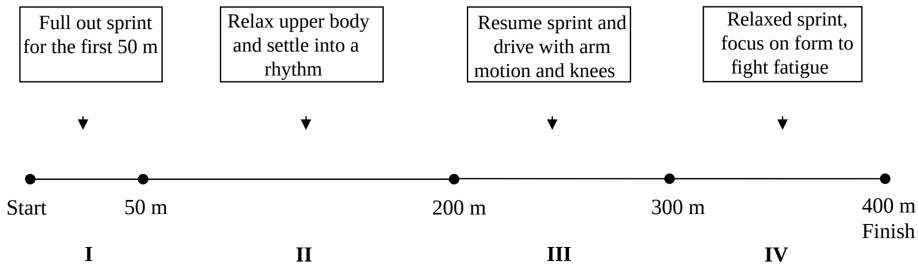

Figure 13.1 Segmented strategy for the 400 m dash.

I asked Charlie to write down the strategy his coach taught him to run the 400 m dash during competition. Based on this information I was able to portion out the race and address each segment individually (see Figure 13.1).

I first wanted to determine how Charlie's self-confidence was influencing the quality of his performance, therefore I implemented Bandura's (1997) model of self-efficacy. Bandura defined perceived self-efficacy as "the beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). Utilizing the guidelines set forth for constructing self-efficacy scales, I devised a scale to determine the level of self-efficacy Charlie perceived for each segment of the race. The strength of self-efficacy was assessed by asking Charlie to rate the degree to which he felt confident in his ability to execute a particular segment of the race (e.g. "How confident are you in your ability in executing segment II of the race in order to secure a top-place finish?"). Response options were based on a scale that ranged from 0 (*not confident at all*) to 100 (*extremely confident*). The same questions were asked for segments I, III, and IV.

As seen in Figure 13.2, Charlie felt extremely confident in the initial segments of the race but his efficacy beliefs tapered off dramatically through segments III and IV. Self-efficacy has been shown to be influenced by various sources of efficacy information. Therefore, the next step was to address the sources of efficacy. The

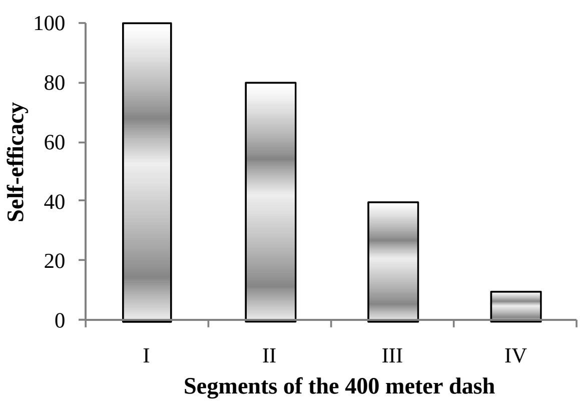

Figure 13.2 Self-efficacy assessment for each segment of the 400 m dash.

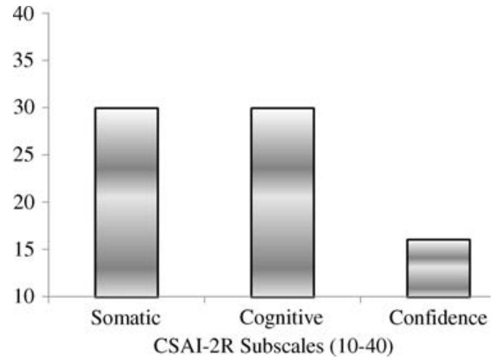

Figure 13.3 CSAI-2R results for each domain.

most influential factor that is known to influence self-efficacy is mastery experience or prior performance, but secondary to that are physiological and affective states (Bandura, 1997). I can't directly change his mastery experiences or prior performances, but can manipulate his affective states and his ability to regulate his emotions. Charlie already expressed to me that he was overly anxious at times during practice and mostly during competition. At this point, I needed to get a better grasp on his thoughts and perceptions of physical anxiety related to performance. To assess his competitive cognitive (i.e. thoughts) and somatic (i.e. bodily reactions) levels of anxiety, I administered the revised version of the Competitive State Anxiety Inventory-2 (CSAI-2R; Cox, Martens, and Russell, 2003). The scale also included an assessment of his overall self-confidence, which was a good follow-up measure to the self-efficacy report.

Charlie was experiencing extremely high levels of somatic and cognitive anxiety, as shown in Figure 13.3. This would manifest as muscular tension, jitters, shakes, and a preoccupation with his nervousness before each race. And as expected, his confidence was low. Noted by Martens *et al.* (1990), the typical male intercollegiate athlete's perceptions of cognitive and somatic anxiety are usually around 18 ± 4.8. Charlie's anxiety was recorded at 30, which puts him at least 2.5 standard deviations above the mean. In simpler terms, his high levels of anxiety and low self-efficacy were having debilitative effects on his running performance. The results from these assessments underscored the importance of developing a biofeedback-based intervention designed specifically for Charlie so he could learn how to regulate his affective states to improve his running performance.

Intervention

A biofeedback (BFB) intervention was designed by utilizing peripheral indices (i.e. electromyography, skin conductance, and temperature) to assist Charlie in learning how to regulate his negative affective states, improve his confidence, and ultimately, his performance. The treatment took place in a small office that included a couch, desk, and BFB station. The ambient temperature in the office was regulated at a constant to ensure no interference with the BFB modalities. The BFB station included a small desk, computer, BFB equipment, and comfortable chair for Charlie to sit in front of the monitor.

A desktop computer equipped with BioTrace + Software® Advanced Physiological Monitoring and Feedback by Mind Media B.V. software (US, Roermond-Herten, The Netherlands) was used to manage the data collection acquired from a NeXus-10™ wireless Bluetooth BFB system. I utilized a dual-monitor setup and positioned my monitor in a way that I could view the same screen that Charlie would see without having to distract his concentration by viewing over his shoulder or "crowding" his space.

Electromyography (EMG) was measured in microvolts (μV), which included pre-gelled disposable silver/silver chloride snap electrodes (duo-trode 6145) connected to the NX-EXG2A sensor. Skin conductance (SC) was measured in micromhos (μmho) using the SC/GSR sensor (NX-GSR1A) and Ag-AgCl finger electrodes, which were fastened to the index (pointer) and middle finger of the nondominant hand. Temperature (TEMP) was measured in Fahrenheit (°F) using sensor NX-TMP1A and attached to the ring finger using medical self-adhesive tape on the nondominant hand.

In order to implement the BFB intervention, I utilized the Wingate five-step approach (W5-SA; Blumenstein, Bar-Eli, and Tenenbaum, 2002). The W5-SA (see Figure 13.4) is a protocol designed to provide structure and guidance in the application of BFB interventions and can be adapted and applied to a variety of populations and contexts. The steps include (a) Introduction (i.e. adapting to and learning various self-regulation techniques), (b) Identification (i.e. identifying and strengthening the most efficient BFB response modality), (c) Simulation (i.e. proceeding mental preparation from laboratory to field), (d) Transformation (i.e. preparing for real-world tasks), and (e) Realization (i.e. obtaining optimal regulation in real-world scenarios).

Charlie was at the start of the track season and was devoting most of his time to school and track. I knew his time was valuable, so I had to make the most of our time together and understand that his participation was voluntary and that at any time he could stop coming to see me for assistance. A typical outdoor track season lasts about 3 months. Therefore, I designed the first four steps of the W5-SA to be

Step 1 Introduction	**Step 2 Identification**	**Step 3 Simulation**	**Step 4 Transformation**	**Step 5 Realization**
Introduced to BFB and allowed to adapt to environment.	Identifies and strengthens most responsive BFB modality.	Practices emotional-regulation techniques in a virtual environment.	Trained to understand the transition from simulation to the track.	Utilizes emotional-regulation techniques during competition.

Figure 13.4 Steps 1–5 of the Wingate five-step approach.

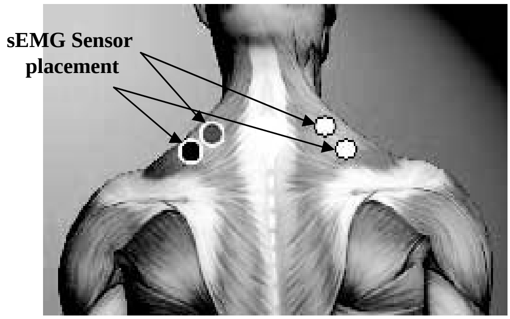

Figure 13.5 Trapezius sEMG sensor placement.

implemented over a 6-week period, which gave us enough time to work through all the steps without rushing and to get him ready to compete in his conference championships. From that point forward, he would work through the fifth step of the process for the remainder of the season.

In the first session, Charlie underwent Step 1 of the five-step approach labeled "Introduction." He was introduced and connected to the BFB channels of EMG, TEMP, and SC and allowed an "adaptation period" to become accustomed to the environment and equipment (Arena and Schwartz, 2003). I utilized channels *C and D* on the NeXus for the EMG signal and placed the sensors on his left and right upper trapezius, parallel to the muscle fibers (see Figure 13.5).

In addition, he was taught the arousal regulation techniques that were used in accordance with Williams and Harris's (2001) recommendations for relaxation and excitation, such as Jacobson's (1930) progressive relaxation techniques and autogenic training with imagery (Linden, 1993). The autogenic training is a six-stage process designed to produce sensations of warmth and heaviness. After Charlie was able to achieve the six stages of autogenic training, I transitioned him to imagery practices with "soft eyes" so he could still view the BFB screen to see how these different techniques were affecting his physiology. I was able to guide him through all these steps using verbal cues.

Concentrated efforts to establish feelings of warmness and heaviness were established for Charlie: "your arms and legs are very heavy. If your mind wanders to some other thought, redirect your attention back to your legs and arms, letting the intruding thought disappear. Become more relaxed and quiet." Next, I moved him to warmth phrases directed at his extremities, breathing, and focusing on cooling his body. I also utilized breathing patterns and verbal cues for the phases of excitation or energizing: "increase the rhythm of your breathing and imagine each inhalation produces more energy and activation. Increase your breathing rate as your level of energy increases." Additional words used were "explode," "psych up," "charge up," and "go." Step 1 was conducted over five sessions and lasted one hour each. A screen designed to display the left and right EMG signals and amplitude was created. SC and TEMP were also displayed in numerical form and as line graphs (see Figure 13.6).

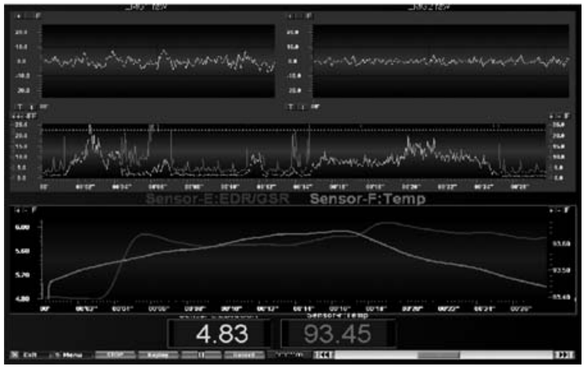

Figure 13.6 Practitioner EMG multiple-signal screen.

In Step 2, Identification, I had to indentify the modality to which Charlie responded most positively and then strengthen that parameter through a series of excitation and relaxation techniques. I worked with Charlie on Step 2 over the next six sessions. Charlie responded positively to the EMG sensors and enjoyed manipulating this modality the most and was the focus in Step 2. Specifically, by utilizing the EMG sensors, my goal was to have Charlie practice moving from relaxation to excitation and back from relaxation to excitation quickly and accurately. I wanted him to achieve relaxation within the limits of 0.8–1.0 μV and excitation within the range of 2.0 + μV. I placed the sensors during different exercises in a variety of locations including the upper trapezius, deltoids, calves, and forearms. Similar to Step 1, I guided Charlie by using autogenic training with imagery and the excitation and relaxation exercises, but this time only with the EMG sensor. As seen in Figure 13.7, a ball on a balance beam provided Charlie feedback based on his level of relaxation or excitation. The ball rolled left to indicate his level of relaxation and moved right to indicate tension.

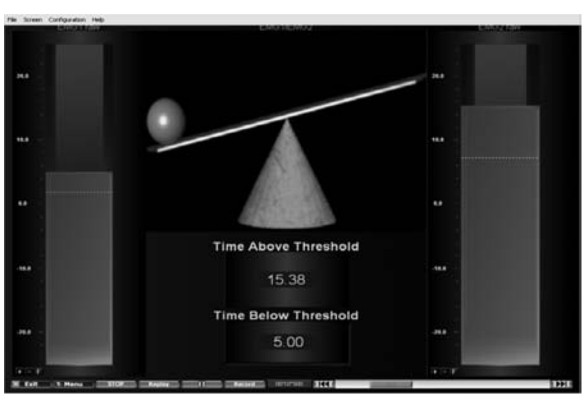

Figure 13.7 Client EMG training screen.

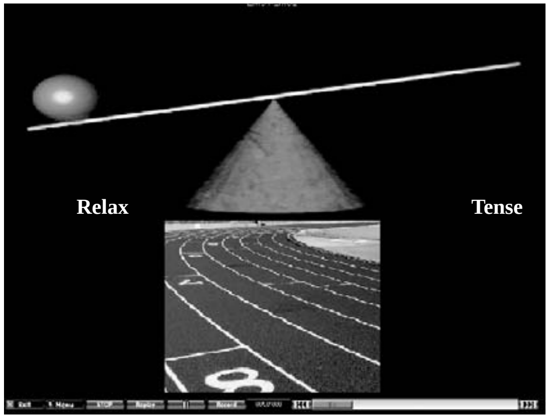

Figure 13.8 Video embedded in client EMG training screen.

During Step 3, which is titled Simulation, I had Charlie start practicing some arousal regulation techniques while watching videos scenes. I was able to conduct Step 3 over 4 sessions. I had Charlie bring in at least three different videos of his races in the 400 m dash. I was able to integrate the videos into the BFB screen (see Figure 13.8). I had already segmented the race out into four sections, which partly determined how I approached the training in Step 3. I connected Charlie to the BFB equipment, including the SC and EMG sensors. Before I started the video, I had him work on some progressive relaxation starting with his feet and moving all the way up to his chest and neck. After he completed the first round of relaxation, I started the video. I asked Charlie to appropriately charge himself up as if he were really competing. I wanted him to emotionally follow the race through each segment as if he was actually in the moment. As seen in Figure 13.1, Segment I of the race starts with a full-out sprint. His goal was to try and peak his exertion while watching the video, then slightly relax as if transitioning into a rhythm sprint for Segment II, then slightly exert himself again for Segment III, and then push through the final segment. We practiced this using all three races, and before and after each viewing he worked on his imagery and relaxation to bring his levels back down to or below his baseline.

I personalized the imagery for Charlie to use during the BFB sessions and at the track. The program essentially guided him through a prerace routine as well as the segments of the race. The imagery was designed in way to allow him to become more internally focused while he was in the starting blocks, as well as to keep his attentional focus narrow. This facilitated his reaction time at the start of the race thereby allowing Charlie to get quicker starts. The program involved a combination of internal and external imagery and required him to emphasize using all of his senses (i.e. seeing, feeling, hearing, and smelling). I also incorporated some of his personal preferences of what he wanted to see involved in the imagery (e.g. I am swift and fast, I am as quick as a cheetah).

In Step 4, Transformation, I had Charlie utilize all that he had learned in Steps 1–3 to prepare for an upcoming meet that his school was hosting. I received approval from his coach to attended three separate practices with Charlie and guided him through some of his arousal regulation techniques to make sure he felt comfortable utilizing these techniques without the use of BFB. In preparation for the track meet, the coaches were not pushing the runners too hard during practice; therefore, it was a good time for me work with him on his mental preparation during these sessions. We had one more preparation session scheduled for the lab, so I had Charlie come in to the lab and practice one more time using the procedures detailed in Step 3.

During the next two weeks, Charlie competed in his school's invitational track meet and then his conference championships. In Step 5 (Simulation) of the process, Charlie had to apply in actual competition all that he had learned from Steps 1–4. This included progressive relaxation and autogenic training when Charlie felt nervous, and excitatory methods if at any time he felt that he needed to "amp" up. After his two competitions, I collected another round of self-efficacy measures and I administered the CSAI-2R.

Outcomes and Discussion of Findings

Charlie responded positively to the BFB training and verbally reported the enjoyment and effectiveness he associated with the process. I emailed him following his conference championships to ask how the meet went, and he responded, "I'm surprised what a difference all this biofeedback training has made and helped me get my mind 'right' so I can be a better runner!" After successfully guiding him through the W5-SA and consulting with him during a couple of his competitions, I had him complete the self-efficacy and CSAI-2R assessments at that time.

Charlie's perceptions of Somatic and Cognitive anxiety were greatly reduced following the intervention, as shown in Figure 13.9. In addition, his perception of confidence also improved dramatically. Charlie stated that knowing that he had been preparing mentally to deal with his nervousness gave him a great deal of

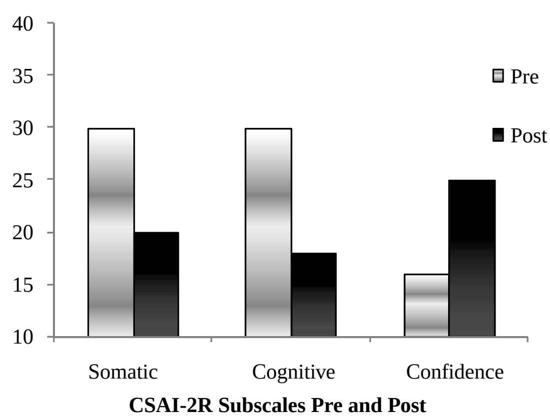

Figure 13.9 Pre- and posttest CSAI-2R assessment.

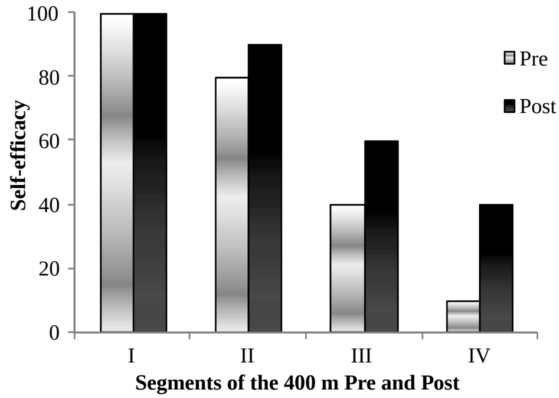

Figure 13.10 Pre- and posttest self-efficacy assessment.

confidence. He said he was still a little nervous, but “in a good way.” His levels of anxiety had become more manageable due to his ability to calm and control his emotions in a way that improved his confidence (see Figure 13.10).

Charlie’s perceptions of self-efficacy also improved a great deal from his initial assessments. He stated that he felt much stronger in the final segments of the race. He said he felt much looser during the races, whereas before he would tighten up, particularly in Segment IV, and finish poorly.

The goal was to help Charlie improve his ability to regulate his emotions and improve his confidence and subsequent performance. He initially started out the season very apprehensive and performing below his standards and the expectations his coach set forth for him. From the time that we started working together to his conference championships he was able to shave a little more than 3 seconds from the time that he recorded in the opening invitational meet of the season. He ran a personal best of 49.87 seconds (see Figure 13.11).

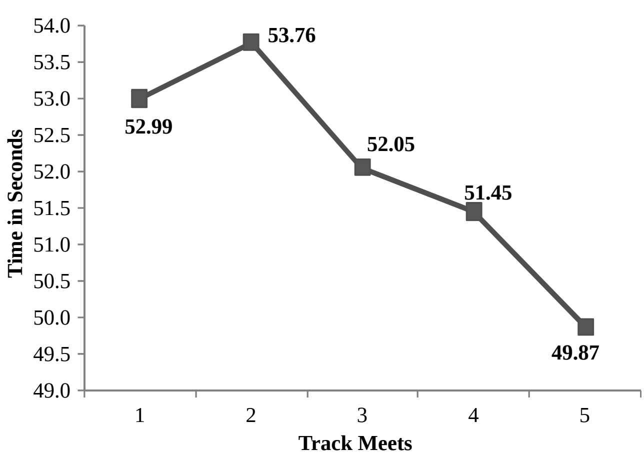

Figure 13.11 400 m improvement times over 5 meets.

Charlie expressed to me that he was very happy with his improvements but he stated he wasn't satisfied and felt like he could run much better times. My feelings are that as long as he can regulate his emotions and keep his confidence at a reasonable level, the rest of the performance improvements are contingent on Charlie's work ethic. Now, it is up to Charlie to continue to get physically faster and stronger through hard work and practice on the field and gym and to continue to focus on regulating the emotional aspects of his game.

Charlie's accomplishments cannot be entirely attributed to the BFB intervention. His accomplishments were primarily a result of his work and practice in the gym and on the track with his coach and teammates. However, the intervention served as a mediating variable that allowed Charlie to move past his inability to regulate some of his negative emotions, improve his confidence and focus on the important technical aspects of training and the actual race. From a theoretical standpoint, addressing his physiological and affective sources of efficacy information nurtured aspects such as motivational commitment, resiliency to adversity, and performance accomplishments (Bandura, 2000; see also Feltz, Short, and Sullivan, 2008). Specifically, once Charlie learned to manage his emotional states more effectively through BFB he was able to improve his sense of self-efficacy, which contributed to enhanced and sustained levels of running performance.

When working with most clients, particularly student athletes, it is difficult to get them to adhere to the treatment protocols and, quite frankly, show up to every meeting. The W5-SA was an excellent protocol for this particular case. The protocol allowed for adjustments based on the circumstances and the specific needs of the client. Considering that Charlie was a full time student and also competing and practicing during the time we were working together posed some challenges. In the initial sessions, I was able to describe to Charlie the procedures of the protocol, which spiked his interest and, because of his inherent competitive nature, provided some incentive for him to achieve the goal set before him. Charlie was very dedicated to the process and attended all the meetings we scheduled. He would come to the lab between classes or after practice, but was often mentally and physically very tired. I would usually spend the first fifteen minutes allowing Charlie to "decompress" and ease into the process. During this time I was able to ensure that all the equipment and software was functioning properly. Another important note, I was also able to establish a relationship with his coach, which provided me with additional information on Charlie's case and fewer barriers to working with Charlie when I attended his practices.

The BFB equipment and computer equipment are usually very reliable but inevitably there are always some types of glitches that needed to be worked through. On a couple of occasions, I ran out of battery power and had to replace the batteries and restart the program. In addition, on two separate occasions the program froze because Charlie had his phone in his pocket with his blue-tooth function enabled, which interfered with the BFB blue-tooth signal. When possible, I attempted to show up early to the lab, turn on the computer, and set up the BFB equipment with all necessary sensors prepared to be attached. This allowed me time to reconfigure or work out any unexpected kinks that may slow down the process. The focus was to deal with and help Charlie's affective regulation issues and not have to worry about network connections, battery life, software issues, and BFB hardware issues.

Charlie ended the season on a strong note by beating his personal best time, and he further expressed to me that his confidence was high and his spirit remained strong. He enjoyed working with the BFB so much he would come to the lab to experiment with different forms of BFB and strengthen his ability to regulate his affective states. Charlie also mentioned that his relationship with his coach had improved and he was enjoying spending more time with his teammates on and off the track.

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14

Case 12 – Traumatic Brain Injury Recovery

A Neurofeedback-integrative Approach

Diane Roberts Stoler

The Brain

The brain is a complex, marvelous, unique connection of nerves, blood vessels and tissues. Its texture is similar to custard in a bowl – soft, pliable and slippery. Yet, it is the center of your nervous system and it receives processes and sends messages to every cell and every part of your body. The information received is from any of our seven senses: sight (Visual), sound (Auditory), touch (Tactile), smell (Olfactory), movement (Kinesthetic), taste (Gustatory) and intuition (Spiritual). The incoming information is initially processed in the protective/reactive (Survival) Limbic areas of the brain. These areas work in a reactive mode to help regulate our bodies and keep us safe. The autonomic system, without thought, regulates the beating of our heart to adjusting the temperature in our body to help us to stop in our tracks and freeze in a dangerous situation. The frontal area of our brain allows for decision making and is the responsive, thoughtful part of our brain that acts as the braking system to prevent over reactivity. Thus, for incoming information to move and be processed, integrated then sent out (Response), the brain must function fluidly. When it does, it is called brain regulation. This means that the brain, the vast network of the brain, is flexible, resilient, and self-regulating. The brain's ability to create new sprouts and branches is call neuroplasicity.

Brain Injury

A head injury does not necessarily mean injury to the brain, nor does a brain injury necessarily come from a head injury. You can bump your head hard enough to

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cause injury to the skull, yet not to the brain. A brain injury is any injury to the brain, at any age of onset, from any cause, such as from an infection, lack of oxygen, genetics, including trauma to the brain. A Traumatic Brain Injury (TBI) is an injury to the brain caused by an external force or impact, such as an automobile accident, a fall, sports injury, assault (firearm), domestic violence (battering) and shaken baby syndrome. A diagnosis of a TBI is given when two criteria are be met. The first is the loss of consciousness and the second is amnesia.

The terms "Mild, Moderate and Severe" to describe a brain injury are not a description of the severity of the consequences, but rather how long a person has been unconscious. The term "Mild" is synonymous with using the word "Concussion," which is a loss of consciousness (awareness of one's environment for up to one hour. After one hour to 24 hours, the term, "Moderate" is used. After 24 hours of loss of consciousness, it is called a Coma. Amnesia is the loss of memory before, of, or after an event.

Repeated brain injuries, including repeated mild concussion, can have severe or fatal outcomes, especially when the second injury occurs too soon, before recovery from the first has taken place. This is called Second Impact Syndrome. The symptoms of TBI are listed in Table 14.1.

Often these areas intertwine and each needs to be addressed, yet, it is extremely important to look for the core issue and from this vantage point. Once this is done, determines the specific approaches of neurofeedback that are available.

When there is a brain injury, the system becomes deregulated or, in other words, the brain becomes stuck in specific brainwave patterns. Thus, it no longer is resilient, flexible and often it becomes over-reactive (hyper-arousal – anxiety). When this happens, to protect itself, it shuts down causing (hypo-arousal, depression, fatigue, inattentiveness). The goal of neurofeedback integrative approach is to help regain a resilient brain and mind and return your life to its optimal level.

Types of Biofeedback and Neurofeedback

Traditional neurofeedback: This is based on operant conditioning and helps retrain the brainwave to optimal level. Methods include Othmer's low frequency; Paul Swingle Method; Kirt Thornton Gamma Coherence, Nancy White's alpha/theta training and Robert Thatcher Zscore training.

LENS (Low Energy Neurofeedback System): This system, developed by Len Ochs, is based on restructuring the stuck patterns in the brain and to promote a balanced flexible state.

NeuroField: This system developed by Nicholas Dogris, allows the body to engage its own restorative systems so as to return to a balanced, homeostasis state. Specific amplitude and frequency changes can be measured for the purpose of guiding the brain so that it can function more effectively. NeuroField was designed to strengthen the body and promote healthy, balanced states.

Table 14.1 Symptoms of traumatic brain injury.

Physical difficulties

- Fatigue
- Sleep disturbances
- Headaches
- Dizziness
- Nausea and vomiting
- Blurred vision
- Hearing problems
- Sexual Dysfunction
- Loss of sex drive
- Ringing in the ears
- Sensitivity to light and/or sound
- Falling asleep or waking up in the middle of the night
- Nightmares/flashbacks
- Waking up alert, yet soon feeling exhausted
- Tremor in hands or legs

Cognitive (thinking) problems

- Distractibility
- Disorientation
- Temporary amnesia
- Memory loss
- Short-term memory loss
- Poor judgment
- Slow thinking
- Unable to focus
- Problems with memory
- Forgetfulness
- Problems with speaking
- Finding the right word to say
- Feeling confused

Emotional difficulties

- Depression
- Agitation
- Apathy
- Irritability
- Anxiety
- Fear of "going crazy"
- Frustration or anger
- Guilt or shame
- Feelings of helplessness
- Changes in mood

Behavioral issues

- Confrontational attitude
- Explosive temper
- Fearfulness
- Impatience
- Thoughtlessness

Neurofeedback integrative approach

Regardless of the presenting problem or situation, it is important to see every individual from five distinct views:

- Physical
- Psychological
- Emotional
- Spiritual
- Energy

Personal Roshi ("pRoshi"): Developed by Chuck Davis, this is a light machine used to disrupt inefficient patterns in the brain. The lights flash at a constantly varying speed, helping the brain to "get out of the rut" of current dysfunctional patterns.

Infrared light as a healing modality: The infrared light is used to calm the nervous system, reduce spasm and spasticity, relieve pain and reduce inflammation. Two devices that are often used are a cold laser and/or the photonic stimulator.

HEG (hemoencephalography): This measures the blood flow in the brain and gives feedback to encourage blood flow to the targeted regions. This was specifically designed for helping with migraine headaches and depression.

HEG pIR (passive Infrared HEG): Jeffrey Carmen's system, measures infrared temperature off the forehead.

HEG nIR (near Infrared spectroscopy HEG): Hershel Toomin's system, measures oxygenation of cerebral blood flow.

HRV (Heart Rate Variability): This measures the heart to brain communication to help regulate and bring balance to the autonomic nervous system and limbic system.

CES (Cranial Electrotherapy Stimulation): This system produces tiny "micro-currents" which are thought to stimulate the areas of the brain responsible for neurotransmitter and hormone production. Thus, this method is another used to bring regulation to the brain.

AVS (Audio/Visual Stimulation): Through light and sound in coordination together, this machine is used to bring balance and regulation to the brain.

Additional Modalities

Along with the wide variety and areas of neurofeedback mentioned above, additional modalities are used to address other areas of the brain/body system to provide the neurofeedback integrative approach. The additional modalities include those listed in Table 14.2.

Table 14.2 Additional modalities.

o Neuropsychology	o Nutrition education
o Neuropsychological testing	o Water therapy
o QEEG, brain mapping	o Therapeutic massage
o Tomatis Method®	o Irlen Method®
o Physical therapy	o Bach Flower Remedies
o Speech/language therapy	o Essential oils (aromatherapy)
o Cognitive therapy	o Hypnosis
o CranioSacral therapy	o Cognitive behavioral therapy
o Reflexology	

Two Case Studies

The two cases presented are at the vast extremes. Ms A was diagnosed with mild traumatic brain injury (mTBI), while Mr T had a severe traumatic brain. Even though their background and amount of time unconscious were vastly different, both received the neurofeedback integrative approach and both have had remarkable outcomes.

Case 1: Presenting problem

Ms A, a single, very pleasant, right-handed, 16-year-old female, junior at local regional high school, experienced three major accidents in a $1^1/_2$ year time period. Her chief complaint was chronic pain that included constant headaches and generalized pain and discomfort. Other symptoms were chronic fatigue, problems falling asleep, remaining asleep, concentration, dizziness, short-term memory, low energy, and feeling emotionally isolated from peers.

Because of her chronic fatigue and sleep problems, Ms A had a hard time getting up in the morning to go to school, causing Ms A a lot of frustration. Ms A was unable to keep up with her school work because of her difficulty concentrating in class and did not know how to deal with these changes. She reported that her life had totally changed and she didn't know how to deal with it.

Her friends and classmates did not understand what was wrong with her because the symptoms were not visible. Thus, she did not have their support. Meanwhile, the high school educators were not very understanding to Ms A's needs, adding to Ms A's depression and frustration. The lack of understanding from her high school also caused a lot of stress within Ms A's family. In a special needs conference while developing Ms A's education plan, the team concluded that Ms A, who had been a straight "A" student, probably would not graduate high school.

Ms A visited many doctors but none was able to diagnosis the cause of her pain and other symptoms that she was experiencing. After the third accident, Ms A's depression really set in and she experienced fear of getting back into a car and Ms A did not get her driver's license until she was 18 years old due to her extreme fear of driving, making it hard for Ms A to hold a job, go to see friends, or have any freedom. Ms A did not want to go back to school and did not want to go see another doctor. She was skeptical at first when she came to our office because other doctors were unable to help her thus far.

All Ms A wanted was for her constant pain to stop and to be able to get back into the things she was good at before the accidents. She wanted to finish high school and go to college and meet new friends. She needed to regain confidence and needed encouragement to get better and move on.

Background information

Prior to these accidents Ms A was a high honor student with perfect attendance. She was an accomplished musician of several instruments, was involved in school plays, student council, and band. Also, her mood, affect, and ability to concentrate had all been normal. She had a stable family environment.

The first accident occurred in October 2004. The accident was a hit and run, where Ms A and her mother were hit from the rear by another vehicle and their car spun 180 degrees. The impact made Ms A, who was wearing a seatbelt and cross-strap, hit her head and banged into the door causing a whiplash. There was no reported loss of consciousness, change in consciousness or post-traumatic amnesia. Ms A recalled that the car had spun. She and her mother did not seek medical assistance that day. The next day, however, Ms A's elbow hurt. One week later, X-rays were taken. There were no broken bones. A few weeks later, she began to experience substantial neck pain and headaches. Ms A and her mother did not perceive that there were any immediate changes in attention, concentration, memory, or thinking abilities.

Ms A's first semester grades were all "A"s; however, by the second semester her grades began to slide and she had problems attending classes. As time passed over the next several months, Ms A had increasing difficulties with awakening, falling asleep, and chronic fatigue, and experienced other symptoms of Post Concussive Syndrome, including substantial chronic pain in her neck and back. She saw a chiropractor, physical therapist and massage therapist, without any relief of her pain. Thus, she entered into a pain management program at a major rehabilitation hospital in Boston. This too, proved to be ineffective.

The second accident occurred in June 2005 when Ms A was 15 years old. Ms A was a passenger in a car being driven by her mother. She was wearing a seatbelt and a cross strap restraint. There was slow-moving traffic, when their car was hit from behind by another vehicle traveling at a speed of approximately 25 mph. Again, Ms A experienced a whiplash. In this accident, Ms A did not hit her head. There was a brief loss of consciousness, yet she had full recall of the event. However, the pain in her neck and back intensified.

The third accident occurred in December 2005. In this accident, Ms A, wearing a seatbelt and cross strap restraint was again a passenger in her mother's car. They were stopped at a stop sign when a large pick-up truck crashed into their car and pushed the vehicle into the street. For a third time, Ms A experienced another whiplash. There was a brief loss of consciousness and confusing of recall of the event. This time Ms A was taken to the emergency room by ambulance, X-rays were taken and the findings fell within normal limits. No MRI was performed. All three accidents were extremely traumatizing to Ms A and left her in a state of shock after each incident.

Assessment

The assessment phase of the neurofeedback integrative approach includes assessment by the entire team. Thus Ms A had an assessment by each of the team members. She had several QEEG's performed; neuropsychological testing; an auditory assessment; CranioSacral/physical therapy assessment; visual assessment; medical assessment; neurological assessment; water therapy assessment; speech/language assessment and a nutrition assessment. Her pain threshold on a scale of 1–10, with 10 being the worse, was between 6–10 daily. Also, the intensity from dull to sharp, on the same scale was 5–10 daily.

Based on the results of all the assessments, a diagnosis was attained and a treatment plan was developed.

Diagnosis

Dual Diagnosis Code

Axis 1: 316.00 Psychological Factors Affecting a Medical Condition/Brain Injury
307.89 Pain Disorder Associated with both psychological and general medical condition (Brain Injury)
Axis 2: N/A
Axis 3: 907.07 Concussions Late Affect Injury
Prognosis: Good to Excellent
Medication: None

Treatment plan

1. Purchase and use an FDA approved medical device: Cranial Electrotherapy Stimulation (CES) for her depression and insomnia.
2. Revise her diet to a higher protein diet and purchase vitamin supplements to aid in brain recovery.
3. Suggested readings: Jean-Caper "Your Miracle Brain" and Andrew Weil, "Eating Well for Optimum Health."
4. Cognitive Training 1x per week to help reorganize and plan her daily activity.
5. Reading and Comprehension training with Eye-Q software from Infinite Mind. This software helps to increase reading comprehension and eye movement training.
6. Acupuncture and/or hypnosis 1x per week for pain management.
7. CranioSacral Therapy and Massage Therapy 1x per week for pain management.
8. Water therapy at Burdenko Institute 1x per week plus 2x per week at local pool. Water therapy helps with chronic pain syndrome.
9. Sound Therapy (Tomastis®/iListen®) 30 minutes daily for 3 months.
10. Psychotherapy-Cognitive Behavioral Therapy 1x per wk and Family Therapy 1x per month.
11. HRV 2x per week
12. Neurofeedback 2x per week at the office and 5x per week at home.

Specific neurofeedback intervention

The above treatment program was in effect for approximately two years, from October 2006 to August 2008. Ms A had neurofeedback training 2x (60 min) per week at the office along with 5x per week home training. During that time, the neurofeedback protocols that were effectively used were the following:

1. C3/C4 Peak Performance training C3-15-20 hz up training/C4-13-15 hz up training, while suppression of 4–8 hz and 20–32 hz (Protocol for daily home training).
2. Started with 01/02 alpha/theta training for 20 minutes to regain restorative sleep. This one protocol is essential for the brain to reset itself and help the neuroplasicity of the brain. During this protocol, simultaneously pRoshi magstim are used over the eyes (also part of daily home training).
3. Often the first half of that session they used the red/blue setting on pROSHI glasses, and the second half of the session we switched to light blue MidiFlash. The session concluded with iListen® TLP therapeutic music (full spectrum, with nature sounds).
4. F3 up training 15–20 hz with clear pRoshi or MidiFlash.
5. On the days when Ms A reported being extremely tired after doing the alpha/theta training, Zscore training was done for 20 minutes F3/F4-01/02. During this training iListen® De-stress and blue/green setting on pROSHI glasses were added. After this treatment, Ms. A would report being more alert and refreshed.
6. During a specific neurofeedback session, Ms A was dealing with allergies. The protocol was to work on improving the sensory motor strip as well as continuing to enhance motivation. Neurofeedback treatment was as follows: C3-C4 2-channel 12–15 with clear blue MidiFlash for 12 minutes. During particular sessions Ms A showed high delta and theta which decreased during training; proceeded to train Fz 15–20, also with clear blue MidiFlash for 12 minutes. Again, delta and theta were high, but Ms A was able to decrease with coaching. Ms A continued to conclude sessions with iListen® Inspiration along with drawing for 25 minutes to the end of sessions. After this session, Ms A reported feeling well and it was noted that her sniffling from allergies had ceased.
7. One day Ms A reported being particularly frustrated with her poor memory; neurofeedback treatment was as followed: Zscore Z%OK coherence training F7-T5 with linked ears for memory for 15 minutes. Ms A concluded the session with 10 minutes of therapeutic listening.
8. In conjunction with Zscore training at F3/F4 and P3/P4, the use of the Eye-Q software by Infinite Mind, which increases the brain's learning and processing ability through a series of high speed imaging exercises, was used. The eye training in each session strengthens the eyes and increases peripheral

vision, allowing Ms A to take in more material at once. The imaging engages more of our right brain and the high speed imaging stimulates the neuro-pathways, strengthening the eye–brain connection and improving our thinking and reaction time. Aromatherapy was used to help Ms A balance emotions and for emotional release. Different essential oils are used to balance emotions.

Reassessment

Periodical brain mappings were performed to assess improvement. Some were full QEEG's, others were MiniQ's and also TLC assessments. Based on this information, adjustments were made to her treatment protocols. In 2007, another neuropsychological test battery was performed.

Results

From the treatment presented above, Ms A was able to return to high school full time and graduated in June 2008 with high honors. She was able to obtain a driver's license, full-time job and perform again as a musician in a string quartet.

Ms A continues to use her CES machine when tired. She reported feeling more rested more alert and less tired following CES treatment. Ms A also had a growth in overall cognitive skills using the Eye-Q software. Using the Eye-Q software, Ms A was able to absorb information more quickly, helping her performance in school. She expressed that through these various neurofeedback integrative approach treatments that she was smiling and laughing again and could see the vast difference in herself. Her daily pain level is now 0–3 and is just a discomfort in her life. Ms A is now a junior at a prestige college in New England and is on the honor role. She no longer needs her neurofeedback equipment. Ms A passed it forward and donated her equipment to another person for their home training and recovery.

Case 2: Presenting Problem

On October 8, 2003, Mr T, a 21-year-old, right-handed, personable male, walked into the office unable to recall anything. He had severe post-trauma amnesia. He had halted, slurred speech. When he spoke, he sounded as if he were intoxicated. Also, he had problems focusing and had experienced double vision at times. This caused him great fear because he was an all state high school baseball player and he feared that he would never play baseball again. Along with this, he had a shaking right leg, problems sleeping, chronic fatigue, confusion, difficulty, concentrating and unable to comprehend what he read.

Background information

Mr T at the age of 15, was diagnosed with general seizures. He had passed out when he was taking a shower and fractured his skull. He was placed on Tegretol and was seizure-free from thereafter. In June 2002, Mr T had graduated from a local regional high school with a full athletic scholarship. He had everything going for him. He was a top baseball player; had lots of friends and a beautiful girlfriend. He was heading off to Wheaton College to be their starting shortstop which he had been dreaming of for two years. Everything was perfect. Then, on August 14, 2002, Mr T drove into a tree on his way to his girlfriend's house and nothing has been perfect since. He was taken to a local hospital where they didn't think he would survive the crash and was then rushed to Beth Israel in Boston. He was in the TSCU for about eight weeks in a coma. Everyday things were touch and go.

Finally, he was well enough, and even though he was still in a coma, was transferred to Spaulding Rehabilitation Hospital in Boston, MA. He gradually woke up and stayed there until December 15, 2002. During his stay there, Mr T had to wear a knee brace because his foot would not go up. Most of his bodily injuries were better by the time he was discharged. Then he was transferred to the Middleboro Nursing Home where he stayed for six very long weeks and then went home. At that time, he went to Community Rehabilitation Care (CRC) in Malden for outpatient therapy. He would be taken there by "The Ride" and driven back home every day. During this time, Mr T could not even remember how to take the elevator up to the office so office staff would come down and get him. At CRC he had physical, cognitive, and occupational therapy. This continued for seven months to completion.

When Mr T was home, his mother felt he was getting depressed and needed to talk to someone. She remembered that Mr T's father mentioned a doctor in the local area who was a sports psychologist and knew something about brain injuries. She called the office looking for help. When Mr T began neurofeedback treatment, he couldn't remember three words or what had happened minutes before.

During his course of recovery, from October 2003 until the present time, Mr T has had numerous bouts of seizure activity, after which his delta activity was extremely elevated. Thus, his therapy had to work with the recovery of his severe brain injury, severe amnesia, and ongoing breakthrough seizures.

Assessment

The assessment phase of the neurofeedback integrative approach includes assessment by the entire team. Thus Mr. T had an assessment by each of the team members. A QEEG was performed; neuropsychological testing; auditory assessment; Cranio-Sacral/physical therapy assessment; visual assessment; medical assessment; neurological assessment; water therapy assessment; speech/language assessment and a nutrition assessment. Based on the results of all the assessments, a diagnosis was attained and a treatment plan was developed.

Diagnosis

Dual Diagnosis Code

Axis 1: 799.0 Inner Cranial Fracture/Severe Brain Injury
294.0 Amnesic Disorder -Severe Post trauma amnesia/Brain Injury
Axis 2: N/A
Axis 3: Brain Injury
Prognosis: Good
Medication: Tegretol XR 12000 mg. and Lamictal 400 mg. 2x daily

Treatment plan

1. Neurofeedback 2x per week in the office, plus 5x per week home training.
2. Cognitive Behavior Therapy when needed.
3. Cognitive Therapy to help organize his life when needed.
4. CranioSacral Therapy 1x per week.
5. HRV 2x per week
6. pRoshi 2x per week
7. Irlen® Glasses
8. Tomatis® Method and iListen®- 3 months.
9. Revise his diet to a higher protein diet and purchase vitamin supplements to aid in brain recovery.
10. Eye-Q from Infinite Mind.
11. Bach Flower Essence
12. Mr T had the opportunity to meet a client who was a VIP all star athlete and received a personal letter and book from Michael Jordan, Mr T's all-time hero.

Specific neurofeedback intervention

Since October 2003, all or parts of the following protocols are still being done. Mr T has neurofeedback training 1–2x (60 min) per week in the office along with 1–5x per week home training. During that time, the follow are the specific neurofeedback protocols that were effectively used:

1. Based on QEEG and TLC assessments, which showed excessive delta and theta in the frontal area of the brain, initial treatment on October 28, 2003 was decreased theta at FZ and increased theta at PZ. Also, the light/sound machine was used. The results were that he felt less brain fog and was more alert.
2. HRV was used in conjunction with C3/A1 Beta enhanced and C4/A2 Lo Beta enhanced while inhibiting Theta and High Beta.

3. Consultation with Nancy White took place about Mr T's sleep issues. O1/O2 alpha theta training was used to help with restorative sleep. Once this was balanced, we started seeing improvement in the frontal areas. Note: there were a lot of changes in enhancing or inhibiting delta, theta, and high beta until this was stabilized. Due to his sleep and breakthrough seizure problems, this protocol is part of Mr T's daily home protocols.
4. As part of his home protocol is also F3/F4 2 channel training enhanced beta and Lo Beta while inhibiting theta and high beta.
5. Consultation with Kirt Thornton took place and used Coherence training at O1/O2 and also at F7/F8. This protocol helped vastly to decrease delta. This method is one that is used whenever delta cannot be decreased by any other method.
6. To help with Mr T's problems with his vision and halted speech, the protocols were 13–18 from F4/P4 to help vision, while F3/P3 for memory (15–20 hz). For his speech F7/A1 and Fp1/A2 really helped.
7. Mr T had great results with P3/A1 P4/A2 enhanced alpha and theta, while F3/A1 and Fp1/A2 to enhance Beta. Using FZ/PZ SMR, Mr T continued to show improvement with his memory and sight and also helped the shaking leg.
8. Fp1/C3 doing beta up mono polar was used for his obsessing thoughts.
9. BioExplorer- F3 and F4 asymmetry and C3 beta up.
10. George Martin spent $3^1/_2$ hours writing specific coherence training for Mr T; 10 minutes of covariance at F7 linked ears F4; then did 44 hz coherence training at the same site, followed by C4 (SMR) training. Mr T reported he felt more alert.
11. F7 linked ears P3 and F7 linked ears C3, both coherence and covariance training. Both Mr T and his mother noticed he is more alert.
12. Did C3/C4 linked ears, covariabilty and Gamma coherence, then followed with C3/A1 and C4/A2 Peak Performance.
13. To help with regaining his reading and comprehension ability, F7/F3 gamma coherence training was done while simultaneously doing the reading software program, Eye-Q from Infinite Mind. This later became one of his daily home protocol and assignments.
14. Consultation with Paul Swingle took place about the continual high delta and alpha. He suggested trying FZ inhibit alpha and PZ enhance Alpha. This really made a shift.
15. The Othmer Low frequency T3/T4 was used to help with the aftermath of Mr T's seizure activity.
16. LENS was performed on a limited basis because Mr T gets too spacey or has had rebounds that throw off his sleeping pattern. Yet, when used occasionally, he can see some benefit. Eventually, LENS became an effective method.
17. When Zscore became available, the protocol of F7/F8 + P3/P4, or F3/F4 + O1/O2, F3/F4 + P3/P4 is used. Since the use of the Zscores, Mr T has made a major breakthrough in his recovery.
18. Neurofield recently was added to his treatment program and is a perfect blend with Zscore training adn LENS. From this combination he made vast improvements in his articulation and mood.

These are often used in conjunction with bi-lateral music – iListen® or Hemi-Sync with pRoshi mag stim or color glasses. This protocol is the present core of treatment along with his home training.

Reassessment

Since October 2003, brain mappings were done periodically to assess improvement and treatment changes. Some of the brain mappings were full QEEGs, others were MiniQs and also TLC assessments. In addition, there were several neuropsychological test batteries done, along with ongoing consults with his neurologist and primary care physician.

Results

Within two months of treatment, his mother will never forget the thrill she had when Mr. T told her that he was sick of eating meatballs every day. This was the first step. Since then, Mr. T has learned how to drive again. In 2006, his dream of going to Wheaton College and playing on their baseball team came to pass. However, the college was not prepared for a person with a traumatic brain injury and the academics pace was difficult. Thus, Mr. T went to a local college for another year. He now has a job at a local YMCA. Both he and his mother reported that they believe that none of this would have ever been possible without the neurofeedback.

Discussion of Findings

What was seen is that regardless of the type or severity of a brain injury is that the brain can recover given the opportunity and the concept of neuroplasicity. Thus, allowing the brain to return to regulation and harmonic balance.

All of the methods used as part of the neurofeedback integrative approach deals with promoting regulation and balancing of the brain/body system. Neurofeedback specifically deals with frequency regulation and balancing. Neurofeedback, in combination with the various modalities, brings about a synergetic effect for healing and recovery of the brain.

The alpha/theta protocol is used to allow the brain to produce restorative sleep and brain regulations. Proper nutrition is an essential component to recovery. There are specific foods and vitamins that allow the brain to heal, while others can do harm. Finding the proper balance is extremely important. Once this foundation is in place, we can then locate the area of damage along with areas of strength. If the brain is stuck in a specific pattern, then the use of methods such as CES, LENS or pRoshi are very useful.

Both of these individuals were able to use the pRoshi or light therapy; however, just as many cannot. Thus, it is not used. As part of the Tomatis® program, the headphones have bone conduction. Over 99% of people with TBI cannot tolerate the bone conduction. In fact, it is almost a way of diagnosing a TBI without a brain map. If an individual asks to have the lights lowered and gets a headache from the bone conduction, then a QEEG is performed, and the results will indicate a TBI.

When Mr T's delta was sky high, Kirt Thornton's Gamma coherence training was used and was found to be extremely effective. However, once this is accomplished, you have to allow yourself to move on and observe what the brain and the person needs next rather than following a cookbook protocol. The Othmer low frequency method is extremely effective with TBI with severe trauma. When retraining a specific area, using amplitude training, phase, or coherence training really worked. The Zscore training is still the most useful for brain integration and regulation.

Conclusion

In 1994, prior to the understanding of neuroplasicity, it was believed that a person with a four year post-traumatic brain injury would not recover. Margaret Ayers did not believe this and was among the pioneers in neurofeedback with traumatic brain injury. Ms A and Mr T are living proof how neurofeedback has changed their lives and allowed them to recover and resume living their lives again.

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Further Reading

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Part III

Certification, Equipment, and Future Directions

15

Certification and Ethics in Applied Psychophysiology (90876)

Phillip A. Hughes and Fred Shaffer

BCIA's Mission

Schwartz (1987), one of the founders of the Biofeedback Certification Institute of America, explained the purpose of certification:

> The certification process thereby acts to deter the least competent; to provide incentives for increasing one's competence; to provide an objective and acceptable criterion for persons to assess their own entry-level competence; and to provide others, such as employers and other professionals, with a criterion to assess them in assessing an individual's entry-level competence. (p. 18)

The *Biofeedback Certification Institute of America* (BCIA) was created in 1981 as a nonprofit organization and was renamed the *Biofeedback Certification International Alliance* in 2010. BCIA's mission is to promote entry-level competence and the progressive growth of expertise: "BCIA certifies individuals who meet education and training standards in biofeedback and progressively recertifies those who advance their knowledge through continuing education."

BCIA has advanced this mission by developing rigorous ethical standards, Blueprints of Knowledge, core reading lists, and examinations based on these references for its three main certification programs. BCIA has certified professionals in over 20 countries outside of North America and serves the international community and the field by requiring that its certificants initially demonstrate entry-level competence and agree to follow its rigorous ethical code. Recertification encourages certificants to increase and update their professional knowledge.

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What Certification Means

BCIA certification is not a license to practice biofeedback and neurofeedback. While BCIA certification means that candidates have satisfied entry-level or advanced requirements in biofeedback, neurofeedback, and pelvic muscle dysfunction biofeedback (PMDB), certificants require a government license for independent practice when treating medical or psychological disorders. Licensed certificants must operate within the scope of their license. Unlicensed certificants must be supervised by a licensed professional and operate within the scope of their supervisor's license when treating disorders. Where the government does not regulate the treatment of medical or psychological disorders, certificants should practice in accordance with the laws of their state, province, or country. All certificants must practice within their personal areas of expertise.

Recognition of BCIA Board Certification

Both the Association for Applied Psychophysiology and Biofeedback (AAPB) and the International Society for Neurofeedback and Research (ISNR) recognize BCIA as the certification body for the clinical practice of biofeedback.

BCIA Biofeedback Areas

BCIA certifies individuals with appropriate health care backgrounds in biofeedback, neurofeedback, and pelvic muscle dysfunction biofeedback (PMDB). While individuals certified in biofeedback may use all biofeedback modalities and adjunctive procedures, those exclusively certified in neurofeedback are limited to EEG biofeedback and adjunctive procedures. PMDB certification is only for licensed health care providers who use surface EMG (SEMG), pressure, and urodynamic sensors to treat elimination disorders and pelvic pain.

BCIA Certification Programs

Clinical Certification is available for biofeedback, neurofeedback, and PMDB. This program is designed for individuals with appropriate health care backgrounds who treat medical and/or psychological disorders, either independently under their own license or under appropriate supervision. Applicants must at least possess a bachelor's degree in a clinical health care area from a regionally accredited academic institution. Candidates must document their completion of didactic education and mentored clinical training, pass a certification exam, and agree to follow BCIA's *Professional Standards and Ethical Principles* and applicable governmental and professional rules.

Academic Certification is available for biofeedback and neurofeedback. This program is designed for professionals who utilize biofeedback and/or neurofeedback in educational, research, or supervisory settings and who do not clinically treat medical or psychological disorders. Applicants must at least possess a Master's degree from a regionally accredited academic institution. They must satisfy the same didactic education requirements and pass the same certification exams as clinicians. They must document 10 contact hours with a BCIA-approved mentor that cover basic instrumentation, sensor placements, and personal self-regulation. They must agree to follow BCIA's *Professional Standards and Ethical Principles* and applicable governmental and professional rules. Academic Certificants must complete recertification every four years like their clinician counterparts.

Technician Certification is available for biofeedback and neurofeedback. This program is intended for individuals without a clinical degree who are already employed as technicians and who use biofeedback and neurofeedback modalities under a supervisor's license when treating a medical or psychological disorder. They must satisfy the same didactic education requirements and pass the same certification exams as clinicians and academics. They must document 10 contact hours with a BCIA-approved mentor that cover instrumentation, sensor placements, and personal self-regulation, and complete 20 supervised patient sessions.

Candidates must agree to abide by BCIA's *Professional Standards and Ethical Principles* and follow all applicable laws. While they may attach sensors and treat medical/psychological disorders under supervision as allowed by law, their supervisor is responsible for diagnosis, treatment planning, and patient care. Technicians must complete recertification every four years like their clinician and academic counterparts, however, their continuing education requirements are considerably lower. Both Academic and Technician Certifications are only available within North America.

Levels of Experience

BCIA certifies applicants for each certification program at entry and advanced levels. *Entry-Level Certification* is designed for individuals who want to add biofeedback to their practice or for beginners with limited training and experience who want to achieve entry-level competence. *Certification by Prior Experience* (CPE) in biofeedback, neurofeedback, and PMDB is intended for individuals who have exceeded BCIA entry-level certification requirements through their lifetime experience in the field. The didactic education and experience standards for CPE are more demanding than those for entry-level certification since this program is designed for leaders in biofeedback and neurofeedback.

CPE for Clinicians requires a license/credential for independent practice, 3000 hours of experience, and 100 hours of continuing education. CPE for Academics requires 3000 hours of relevant experience with biofeedback-related instruction and/or research. CPE for Technicians requires 3000 hours of direct, one-on-one experience using biofeedback with clients.

Who Are BCIA Certificants?

An overwhelming majority of BCIA certificants utilize biofeedback in their clinical practice. About 82% of BCIA certificants are licensed health care professionals; 62% are licensed in mental health and 20% are licensed in medical specialties. The remaining 18% of certificants are unlicensed (Neblett, Shaffer, & Crawford, 2010).

What Is the Value of BCIA Certification?

Certificants initially apply for certification to gain credibility (96%), validate their skills and knowledge (86%), achieve professional satisfaction (85%), ensure adequate training (84%), and promote the field (65%). They recertify for the same reasons that they originally sought certification and to update their skills through continuing education (77%). A larger percentage report that the BCIA website is a valuable source of clinical referrals (58%) and their credential helps them obtain reimbursement (37%). BCIA's high retention rate, which includes professionals who have retired, left the field, or passed away, shows that certificants value board certification (Neblett, Shaffer, & Crawford, 2010).

How Can You Become BCIA Board Certified?

Applicants should start at the *Become Board Certified* menu of the BCIA website at www.bcia.org. The *Applicants Start Here* option provides an overview of biofeedback areas, certification programs, and levels of experience to help individuals decide which certification is right for them. The rest of the menu informs applicants about the requirements for certification programs and available didactic programs and mentorship opportunities, and centralizes application materials.

BCIA's Professional Standards and Ethical Principles

Striefel (2003) explained the critical role of ethical standards: "Professional ethical standards help educators, researchers, and practitioners anticipate and identify ethical dilemmas, and make choices that maintain one's professional integrity and protect the welfare of our clients and profession."

BCIA's *Professional Standards and Ethical Principles* covers issues in responsibility, competence, public statements, confidentiality, protection of client rights and welfare, professional relationships, research with humans and animals, adherence to professional standards, and ethics complaint procedures. In this chapter, we will explore practical issues in coding for biofeedback services, scope of practice and touching clients during biofeedback therapy.

Case 1: Coding of Biofeedback Therapy for Insurance Reimbursement

John Smith, licensed clinical psychologist, received a phone call from a potential patient seeking biofeedback training for migraine headache. The patient had been evaluated and diagnosed by a neurologist, who prescribed biofeedback for this diagnosis. During this initial phone call, Dr Smith obtained general intake information, including the name of the patient's health insurance company and caseworker. Dr Smith told the potential client that he would call back to set an initial appointment after receiving written authorization from the patient's insurance company to begin biofeedback treatment.

Following Whitehouse's (2004) guideline of questions to ask when calling insurance companies, Dr Smith contacted the patient's caseworker seeking biofeedback authorization and to determine the appropriate CPT billing code. The caseworker authorized treatment and advised Dr Smith that it was customary with this insurance company to bill biofeedback services as psychotherapy and use CPT code 90806.

Should Dr Smith take the case and submit invoices to this insurance company using this recommended code?

What makes this a difficult question is the recommended code, one that is often debated by psychotherapists offering biofeedback therapy. Some psychotherapists do use biofeedback to achieve objectives relevant to psychotherapeutic goals. Self-regulation of anxiety easily comes to mind. In such a case, billing services as psychotherapy may be most appropriate. Migraine headache, however, is a medical diagnosis, and not customarily the primary concern of the psychotherapy. Since the referral is for a medical diagnosis, the psychiatric coding of biofeedback therapy may be inappropriate.

An alternative view, following a more psychophysiological approach to therapy, might reason that many medical disorders involve elements of both mind and body. It has been reported that as high as 80% of all physical illnesses presented at MDs' office visits are caused or aggravated by stress, anxiety, and unhealthy life patterns (Figueira & Ouakinin, 2008). In cases where no organic cause of the headache can be established, psychotherapy with biofeedback would constitute an appropriate intervention, and coded as such.

Additionally, in this case, this coding question seems resolved by the case worker's approval of the psychologist's service with the instruction to use the CPT code for psychotherapy. As a representative of the insurance company, what else, if anything, is needed? The problem that still remains, of course, is that coding is confusing. There are established Health and Behavior CPT Codes that more accurately describe psychological treatments of a medical disorder, but these codes are not being offered for use by the insurance company. Why not?

Communication with the referring physician, the patient, and the insurance company is the best plan of action for a complex case like this. The referring neurologist may not want to refer the patient for psychotherapy, but wants the patient to receive biofeedback. The patient, who wants treatment for headache, may be confused by a treatment coded as psychotherapy. Finally, the insurance company's caseworker may be unaware that there are other, more appropriate, codes to use. The right course of action calls for additional work and communication by the psychologist along a number of different fronts.

While insurers and "gatekeepers" may instruct one to code biofeedback sessions as psychotherapy, the therapist would be wise to document the date, time, and name of the person who gave this instruction. Obtaining this information in writing would be prudent.

Case 2: Touching

The measurement of physiological activity may require skin preparation and the careful attachment of recording sensors to the human body. While the act of touching the client is an integral part of skin preparation and sensor attachment, Striefel (2007) observed that it has not been adequately discussed in the biofeedback literature. Additionally, some clinicians may feel uncomfortable with touching biofeedback clients due to their respect for body boundaries and the threat of ethical complaints and litigation. Client misunderstanding of perceived clinician discomfort with touching may affect treatment outcome.

Mary Jones, a licensed clinical social worker (LCSW), was considering adding biofeedback to her private practice and sought professional guidance about physical contact with clients. She wanted to know the guidelines for appropriate touching clients when providing biofeedback services. She found these guidelines in the Association for Applied Psychophysiology and Biofeedback publication *Ethical Principles* (2003):

> Caution and common sense are required whenever an AAPB member has physical contact with a client: e.g. in attaching electrodes. Sexual intimacies with clients are prohibited. In addition, touching and massage require client permission and are restricted to those body areas considered appropriate for touch or massage within the realm of "common practice" for one's professional discipline. Touching of sensitive body parts, such as breasts or genitals, is not acceptable in applied psychophysiology and biofeedback practice with the exception of an appropriate medical exam or medical treatment provided by a licensed medical practitioner. Clients can be instructed in electrode placement using visual aids such as diagrams of the body. (p. 3)

To feel comfortable with adding biofeedback to her practice, Mary decided to take the following steps:

1. To establish her competency, she would pursue BCIA Board Certification in Biofeedback.

2. At intake, for clients that she determined appropriate for biofeedback therapy, she would discuss appropriate touching in the context of informed consent.
3. She would tell clients that biofeedback training requires skin preparation and the attachment of recording sensors to the body, that this requires touching, and that she would always ask for their permission to touch.
4. To confirm that her clients understand these procedures, she would ask them to explain their understanding about permissible touch and to sign an informed consent form that covered these points.

Case 3: Scope of Practice

Jane Smith, a licensed marriage and family therapist (MFT) in the state of California, wanted to expand her practice to include biofeedback therapy. She questioned if biofeedback was within the scope of her professional license, so she contacted her state licensing board, the California Board of Behavioral Science Examiners, for an answer. They informed her that a licensed MFT may use biofeedback as a technique so long as they are working within their scope of competence as established by their education, training, and experience (Board of Behavioral Sciences, 2007).

These cases illustrate that ethical professionals are proactive. John sought billing codes that reflected descriptive accuracy over those that would expedite the billing process. Jane sought guidance from her state board to ensure she was working within the scope of her license. Mary found that by going through the process of becoming Board Certified in Biofeedback she could answer her own professional questions for expanding her practice to a new group of clients.

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16

Psychophysiology: Equipment in Research and Practice

Derek T.Y. Mann and Chris M. Janelle

Introduction

In most performance environments, the performer is often faced with an influx of ever-changing, dynamic information that they must acquire, interpret, use to plan appropriate courses of action, and then execute skilled responses. For example, a surgeon must contend with information presented by the case profile, determine the potential for contraindications, and then overcome the demands of modern equipment to be successful. Athletes must act and react to information that is available from teammates, opponents, and implements as well. In both instances, performers are presented with decisions in the face of pressure; pressure that invariably restricts both the time and space to act. Such sources of stress can have profound deleterious effects on physical and cognitive fatigue, impacting attention, cue utilization, and decision speed and accuracy. They can also extract the ultimate demonstrations of performance expertise. The manner by which the performer has learned to cope with or regulate the physiological reactions to the impending performance pressure can have positive implications on self-talk, attention allocation, information processing, cortical activation, and ultimately human performance.

This chapter examines the roles of biofeedback and neurofeedback for enhancing performance. At the onset, we highlight the various modalities amenable for observation and feedback while critically evaluating some of the techniques used to measure these modalities. Since biofeedback and neurofeedback have been directly linked to increasing performance, reducing stress and anxiety, and managing pain, we then highlight the differences between biofeedback and neurofeedback equipment. Given the rise in popularity of these techniques over

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the past half century, it is necessary to highlight several methodological assumptions and limitations of the vast array of devices in the marketplace for practitioners and the lay-person.

Biofeedback and Performance

"Unflappable, confident, supremely focused . . . Tiger's mind sets the gold standard, and it becomes only more apparent as his career churns onward" (Gola, 2008). These were the words frequently uttered throughout the media and around the sporting world, at least until recently. For the first time since 2004, Tiger Woods is not ranked as one of the top two golfers in the world, a result that may be attributed to his personal distraction and struggles away from the course.

> In order to play this game [golf] at a high level, it helps to have a clear mind . . . my determination hasn't changed. It's just that I need to be focused and put things into a proper perspective. (Tiger Woods, as cited in DiMeglio, 2011)

Tiger's career is replete with indelible moments in which he has managed to coordinate both his mind and body through volition to achieve. Ever so prevalent, however, are those missed opportunities in which he appears to have succumb to performance pressures and other distractions. To excel in these opportunities, athletes and other performers (e.g. surgeons, pilots, soldiers, performing artists) must train to improve their arousal control, thought control, muscle tension, and concentration. The use of biofeedback and neurofeedback are two methods that have a long history of demonstrating efficacy for performance enhancement (Wilson, Peper, and Moss, 2006; Zaichkowsky and Baltzell, 2001).

Biofeedback (BFB) is a process that enables an individual to gain insight into the relationship between their mind and body, providing insight into how thoughts affect physiological changes and in turn how that physiology affects performance, and more importantly, how individuals can learn to change their physiological activity to enhance performance. The use of BFB permits the accurate acquisition of physiological activity such as brainwaves, heart rate, respiration, muscle activity, skin temperature, and skin perspiration. These tools rapidly and accurately provide "feedback" information to the user. The presentation of this information coupled with manipulated or consequential changes in thinking, emotions, and behavior can lead to the attainment of a desired physiological state. With sufficient feedback and practice, these changes can be brought about without the continued use and assistance of equipment, thereby permitting the transferability of these skills to the performance arena.

Similarly, *neurofeedback* (NFB; also known as EEG biofeedback) uses precise instruments to monitor, in real time, the activation levels of the brain in response to external stimulation and internal thoughts. The observation of the brain's activity and the feedback provided to the participant can then be used to regulate brain activation while promoting more efficient and effective cortical activity (Biofeedback Certification International Alliance, 2011a).

To better understand the implications for biofeedback we can look at the various systems of the sympathetic and parasympathetic nervous system that are amenable to observation. Of particular importance to the performance domain are cardiac acceleration and deceleration, heart rate variability, muscle activity, skin conductivity, and respiration. Much of the extant research has integrated the several modalities for enhancing the performance of athletes.

Research in the performance arena using BFB has been especially concerned with the implications that emotions, stress, and arousal can have on performance (Gould and Udry, 1994). A number of cognitive and cognitive-behavioral techniques have shown promise for effectively helping athletes cope with the stress and pressure of performance. However, the integration of these techniques with BFB training as a means to prepare for competition has been shown to facilitate cognitive and affective awareness, which can lead to an increased sense of self-efficacy (Bandura, 1997), and is likely to improve the probability of a successful performance.

Arousal regulation strategies learned through the use of BFB interventions are arguably the most crucial performance enhancement techniques (see Blumenstein, Bar-Eli, and Tenenbaum, 2002). In stationary tasks that involve a limited level of exertion such as pistol/rifle shooting and archery, very subtle shifts in arousal levels can affect the accuracy of performance – most likely when levels of somatic anxiety are higher than perceived levels of cognitive anxiety (Gould *et al.*, 1987). Self-regulatory control of somatic sensations is important in these types of sports, since any variation can alter the performance outcome dramatically. Research has revealed that EMG BFB combined with meditation can help athletes in achieving an improved sense of cognitive (Tremayne and Barry, 2001) and physical (Solberg *et al.*, 1996) regulation.

Utilizing somatic methods to improve performance starts with improving self-awareness and focusing on physical sensations of movement, which contributes to enhanced self-regulation and ultimately performance outcomes (Prentice, 1998). Practitioners often encounter difficulty having an athlete focus on specific thoughts and feelings because of the subjectivity related to the specific performance task. However, self-awareness of bodily sensations can give a more objective sense of self. As a result, a BFB approach has been advocated that employs various devices that amplify specific body functions for psychosomatic feedback (Prentice, 1998).

For instance, Zaichowsky (1983) revealed that a BFB training program that included EMG, GSR, and temperature to be an effective strategy in assisting gymnasts to regulate their levels of stress and improve performance. Peper and Schmid (1983) conducted a two-year BFB training program utilizing EMG, GSR, and temperature in conjunction with progressive relaxation, autogenic training, and imagery. The athletes reported that the program enhanced their athletic performance by integrating the mental skills into their workouts and in competition.

Blumenstein, Bar-Eli, and Tenenbaum (1995) applied measures of GSR, EMG, and HR in combination with autogenic training and imagery on the physiological indices of athletic performance. The psycho-regulative procedures of relaxation and excitation were provided in combination with BFB to examine their effect on the physiological and athletic performance variables in an experimental design. Performance was assessed by a 100-meter sprint. They revealed that BFB significantly augmented athletic performance when accompanied by autogenic training and imagery.

Kavussanu, Crews, and Gill (1998) examined the effects of single versus multiple measures of BFB (i.e. EEG, EMG, and HR) and its relation to basketball free throw shooting performance. They were also interested in determining if perceived control and self-efficacy can mediate the relationship between biofeedback and performance. Results indicated that self-efficacy was the only significant predictor of performance accounting for the largest amount of the variance (60%) in the pre- and post-performance conditions. The relationship between BFB and performance was not influenced by either perceived control or self-efficacy.

Bar-Eli, Dreshman, Blumenstein, and Weinstein (2001) examined the relationship between mental training with BFB (EMG, GSR, HR) on the performance of young swimmers utilizing an adapted version of the Wingate Five-Step approach. The results revealed, based on coaches' evaluations and the results from competition, that the experimental group exhibited a substantially greater increase in performance over the control group. Other research using BFB has demonstrated similar findings in shooting (Daniels and Landers, 1981; Hatfield, Landers, and Ray, 1987; archery (Ren, 1995; Salazar *et al.*, 1990), golf (Crews and Landers, 1993), long-distance running (Caird, McKenzie, and Sleivert, 1999), handball (Costa, Bonaccorsi, and Scrimadi, 1984), karate (Collins, 1995), and judo (Blumenstein, 1999).

Although a few studies have supported the use of BFB in sport (Blumenstein *et al.*, 2002), the majority of the studies contain methodological limitations such as a lack of a control group (De Witt, 1980), brief training sessions (Blais and Vallerand, 1986), use of subjective reports for performance evaluations (De Witt, 1980), and the use of BFB in combination with other treatments (Peper and Schmid, 1983), which ultimately confounds the results. These limitations prevent researchers from drawing conclusions regarding the effectiveness of BFB in enhancing performance.

A potential reason for some of the "nonsignificant" findings regarding sport performance is that the BFB measures used are not specific or individualized to the participant (i.e. it is important to consider individual response specificity) (Edmonds *et al.*, 2006, 2008; Lacey, Bateman, and Van Lehn, 1953). This concept suggests that each individual has a characteristic response to stimuli presented during a competitive task engagement. For instance, Edmonds *et al.* (2006) revealed that individuals do respond to different physiological parameters at different rates during competition. Therefore, it is important to determine an athlete's dominant response system and utilize BFB as a tool to influence the dominant response system in order to enhance overall performance.

Neurofeedback and Performance

Unlike peripheral BFB that observes the sympathetic and parasympathetic nervous system, neurofeedback (NFB or EEG biofeedback) monitors central nervous system activity via the measurement and regulation of brainwave activity. Overtime this information is used to train the individual how to regulate and modulate the level of neural activation. Commonly, sensors are attached to the scalp and the raw EEG signal is collected and amplified. The resulting signal in the form of frequency bands is then extracted and decomposed into isolated bands that are representative of neural activation. The level of activation or deactivation within and across hemispheres provides practical and often valuable otherwise covert information regarding the level of cognitive investment, activation, or relaxation an individual is experiencing.

EEG spectral analysis

To better understand the implications of neurological observation and for NFB we need look no further than the psychophysiological performance research that has spanned nearly three decades, helping us better understand the psychological indices of the expert advantage. Researchers have made extensive use of electroencephalography (EEG) and spectral analysis techniques to investigate cortical activation and hemispheric specialization during the preparatory period of self-paced closed motor skills such as golf putting (Crews and Landers, 1993; Mann, Mousseau, Coombes, and Janelle, 2011), archery (Salazar *et al.*, 1990), and shooting (Deeny *et al.*, 2003; Hatfield, Landers, and Ray, 1984, 1987; Hillman *et al.*, 2000; Janelle *et al.*, 2000). Analysis of EEG spectral power, in particular, has revealed that the effectiveness and efficiency of expert performance has a cortical signature that differs from that of non-experts (Deeny *et al.*, 2003; Hatfield *et al.*, 1984; Haufler *et al.*, 2000; Janelle, Hillman, and Hatfield, 2000; Landers *et al.*, 1994). That is, as individuals progressively become more skilled, the cognitive strategies employed during the planning and execution of movement become more routine, demanding fewer cortical resources (Fitts and Posner, 1967; Smith, McEvoy, and Gevins, 1999), resulting in a demonstrable increase in left hemisphere alpha power (i.e. decrease in cortical activity) and performance. The comparison of cortical activation across hemispheres at corresponding reference sites permits an index of hemispheric asymmetry.

Within the extant literature, researchers have demonstrated relatively stable cortical activation across hemispheres in the novice performer, whereas the expert reliably demonstrates a pronounced asymmetrical ratio, characterized by a relative increase in left hemisphere to right hemisphere alpha power. Simply stated, the novice performer requires greater conscious processing (i.e. verbal analytic processing) of the task demands resulting in greater left hemisphere activation (Hatfield *et al.*, 1984). Conversely, the expert performer operates with greater automaticity and sustained visual-spatial processing as indicated by a decrease in the ratio of cortical activation between left and right hemispheres as the time to execution nears.

EEG spectral activity event-related potential

A number of psychophysiological investigations have addressed athletes' attentional and preparatory states preceding task execution (e.g. Crews and Landers, 1993; Konttinen and Lyytinen, 1992; Mann *et al.*, 2011) by evaluating the electro-cortical modalities of event-related potentials (ERP) that occur across a range of frequency bands. According to Fabiani, Gratton, and Coles (2000), ERPs offer additional insight into the cortical manifestations that precede or follow a discrete event. The ERP is derived from the average of multiple responses and represents the temporal relationship of cortical activation to a specific event, thereby providing a time-locked index of the psychological correlates of performance.

Preparatory activity in the general context of sensorimotor transformations implicates an integrated neural path linking perception to action (Toni and Passingham, 2003). As such, slow cortical waves reflect activation of subcortical and cortical mechanisms necessary not only in motor execution but also in its preparation (Rektor, 2003). Slow cortical waves been speculated to play a role in the detection and pairing of task relevant environmental features with specific elements necessary for response execution (Brunia and Van Boxtel, 2000). Accordingly, throughout the preparation and movement phases of skill execution, the visual attention centers (i.e. occipital and parietal cortex) relay the necessary commands to motor regions of the cortex (i.e. motor cortex, premotor cortex, supplementary motor area, basal ganglia, and cerebellum; Vickers, 1996a, 1996b), all of which are reflected in slow cortical waves.

Sport researchers have applied the slow negative ERP paradigm to research with golfers (Crews and Landers, 1993; Mann *et al.*, in press), archers (Landers *et al.*, 1994) and marksmen (Konttinen and Lyytinen, 1992; Konttinen, Lyytinen, and Era, 1999) revealing that elite performance is characterized by an increase in cortical negativity in the period immediately preceding task performance (BP_{peak}), a pattern indicative of the requisite motor program among experts.

Biofeedback and Neurofeedback Modalities

The effective application of both BFB and NFB are contingent on the accurate identification of the stimulus-response pairing and the correct observation of the most salient biological system. For example, the observation and modulation of heart rate variability has been directly linked to the overall health and state of the autonomic nervous system (Berntson and Cacioppo, 2004), with implications for affective regulation (Cacioppo *et al.*, 2004) and self-regulatory control (Applehans and Luecken, 2006) which has been translated into increased sport performance

(Konttinen, Landers, and Lyytinen, 2000; Konttinen, Lyytinen, and Konttinen, 1995). Conversely, NFB has been intimately linked to the level of conscious processing associated with elite level performance. The extant literature clearly supports that the best of the best are able to operate with less conscious control and greater automaticity, results that have been coupled with enhanced performance (Hatfield *et al.*, 2004; Janelle and Hatfield, 2008; Yarrow, Brown, and Krakauer, 2009).

Whether the goal of the practitioner is to modulate stress, monitor cognitive investment, or decrease muscle tension, in order for the practitioner to maximize the performance implications of biological training the appropriate modality must be identified. The following provides a brief a description of the most commonly researched and applied modalities and their underlying biological systems that may yield performance implications. Each description is coupled with a figure highlighting the general measurement recommendations including electrode type, recording site, impedance level, and reference recommendations.

Electroencephalography (EEG)

The EEG is a process for recording the electrical potential at the scalp associated with the cortical activity of the underlying structures. The EEG output is a reflection of the changes in electrical potential (i.e. voltage) over time. As a result, the recording of specific anatomical locations yields insight to various psychological, emotional, and psychomotor functions. Placement of EEG sensors should correspond with international 10–20 system (Jasper, 1958) and meet the general recording recommendations (Figure 16.1; Pivik *et al.*, 1993) to ensure reliable data collection for research and training.

In addition to identifying the regions of interest, the researcher and practitioner must consider the frequency band of interest which can shed further light onto the level of cognitive investment, stress, and consciousness. For example the EEG frequency spectrum can be decomposed into: delta (1–4 Hz), theta (4–7 Hz), alpha (8–12 Hz), beta (13–36 Hz), and gamma (36–44 Hz) which ranges from sleep states to heightened vigilance. The study of expertise, psychomotor efficiency, and skilled motor performance has primarily focused on the alpha frequency band with results indicating, an increase in alpha (decreased cortical activation) activity in the left hemisphere indicative of enhanced performance. Due to the potential training and performance implications of the existing cortical research, the alpha range is also the primary focus of many BFB systems that are used by practitioners in a variety of performance settings.

EEG/ERP

Electrode	Location/Sites	Impedence	Reference	Electrolyte
AG/AgCL	International 10/20	<5000ohms	Mastoid Linked Ears	Yes

Figure 16.1 EEG recording recommendations.

EEG/ERP

Electrode	Location/Sites	Impedence	Reference	Electrolyte
AG/AgCL	International 10/20	<5000ohms	Mastoid Linked Ears	Yes

Figure 16.2 ERP recording recommendations.

Event-Related Potential (ERP)

The ERP is a time-locked recording of cortical activation in accord with the International 10–20 system (Jasper, 1958) and should meet the general recording recommendations for ERP research (Figure 16.2; Picton *et al*., 2000). More specifically, the ERP is the result of an averaging of samples recorded from a continuous EEG that is time-locked to a specific event. As such, the averaging technique draws on the signal-to-noise ratio, such that the components of the waveform not deemed related to a specific event are assumed to randomly vary across samples, thereby rendering only a representation of systematic variation or components of the ERP (i.e. slope, amplitude; Fabiani *et al*., 2000).

For example, the monitoring of cognitive activity during marksmanship permits the pairing of cognition and behavior while the overt behavior (i.e. trigger pull) provides a time-locked event. As a result, the practitioner can reference the event for isolating the frequency and intensity of cortical processing preceding, during and post trigger pull. Furthermore, the recording of behavioral outcomes permits the cortical comparison of success and failure and the cerebral process that may differentiate successful performance from the alternative.

Electromyography (EMG)

Electromyography is a technique used for recording, observing, and measuring the electrical potential (activation) generated during muscular contractions. Given that the primary function of the central nervous system is to coordinate activation of the muscles (Sperry, 1952; Wolpert, Ghahramani, and Flanagan, 2001), the EMG recording provides insight into the CNS activity and more specifically the electrical activity of the motor unit prior to muscular contraction (Andreassi, 2007).

The EMG can be recorded using subdermal applications (such as needle or fine-wire applications) or by means of surface recordings. The noninvasive surface EMG is by and large the most common method in clinical and applied practice, while fine-wire and needle electrodes are reserved for the diagnosis of muscle dysfunction and nerve conduction (Fridlund and Cacioppo, 1986). The reliable and noninvasive nature and the ease of application for most research and applied applications is a clear advantage of the surface EMG.

Surface EMG sensors are typically comprised of silver-silver chloride (Ag-AgCL) electrodes ranging in size from 0.2cm to 1.5cm in diameter. The size and adhesion

EMG

Electrode	Location/Sites	Impedence	Reference	Electrolyte
AG/AgCL .25-1.5cm in dia.	Belly of Muscle	<10000ohms	Bi-Polar	Yes

Figure 16.3 EMG recording recommendations.

medium is directly tied to the location of the electrode placement and should meet the general recording recommendations (Figure 16.3; Fridlund and Cacioppo, 1986).

Electrodermal Activity (EDA)

The measure of EDA can be measured using one of two methods, Skin Conductance (SC) or Skin Potential (SP). In accord with the recommendations of the Society for Psychophysiological Research, Committee Report (Figure 16.4; Fowles *et al.*, 1981), the use of SC is a preferred method over SP due to the biphasic nature of SP and the hypersensitivity of the SP to hydration levels, rendering interpretation difficult and potentially misleading (Fowles *et al.*, 1981; Andreassi, 2007).

The application of EDA is an effective index of arousal, such that SC increases with arousal and decreases with calmness. The application of the EDA to performance has been linked to readiness to perform. For example, gradual increases in SC were significantly related to the level of performance readiness and not muscular effort (Edmonds *et al.*, 2006). Subsequent research has further indicated an inverted-U relationship between SC and performance, cognitive investment, reaction-time, and decision-making (Edmonds *et al.*, 2006; Peper and Schmid, 1983; Wilson *et al.*, 2006). As a result, SC is an effective index of arousal and one's state of readiness to perform.

Eye Movement (EMB)

Eye-movement registration refers to the process of recording the visual search characteristics during a perceptual-cognitive, or perceptual-motor task. The most common procedure is the corneal-reflection method, which records the movement of the eye under the assumption that the central portion of the cornea corresponds with a point of visual interest (Duchowski, 2002; Williams, Davids, and Williams, 1999).

Electrodermal

Electrode	Location/Sites	Impedence	Reference	Electrolyte
AG/AgCL	Thenar Hypothenar Eminence Medial or Distal Phalanges	<5000ohms	Ulnar	NaCL or KCl

Figure 16.4 Electrodermal recording recommendations.

As the eye moves about the visual field, a shift in visual attention occurs. This shift or gaze is the "absolute position of the eyes in space and depends on both the eye position in orbit and the head position in space" (Schmid and Zambarbieri, 1991, p. 229). Therefore, a gaze behavior refers to a specific coordinated action of the eyes and head, which include a saccade, fixation, smooth-pursuit, vestibular ocular reflex, and the QE period.

Of the aforementioned behaviors, the visual fixation is often most pertinent to performance research and is characterized by the tiny eye movements associated with tremors, drifts, and microsaccades (Duchowski, 2002) that are necessary to stabilize the fovea on a specific target, enabling comprehensive stimulus extraction and information-processing (Williams *et al.*, 1999). Recent research has identified the performance implications of a prolonged fixation known as the quiet-eye period (QE). The QE period, a component of the gaze behavior, is a measure defined as the elapsed time between the last visual fixation to a target and the initiation of the motor response (Vickers, 1996a).

Overall, visual search research has confirmed that experts in sport typically exhibit fewer fixations of longer duration (Mann *et al.*, 2007), suggesting a perceptual-cognitive advantage of the expert over their lesser skilled counterparts. Mann *et al.* (2007) further reported the effects of prolonged QE period of experts, suggesting that the final fixation prior to task execution permits the coupling of environmental information with pre-planned motor-programs that have been long established through deliberate practice.

Temperature or thermal BFB

Thermal BFB uses sensors placed on the hands or feet that are paired with a feedback thermometer designed to measure blood flow to the skin (BCIA.org, 2011). During the stress response, the vascular system in reaction to the activation of the peripheral nervous system shunts blood away from the extremities to ensure maximal delivery of oxygen rich blood the brain, heart and lungs. Although this stress response function serves as a survival mechanism, learning to control or regulate this process can aid in optimum performance by minimizing or eliminating the negative effects of acute stress. As a result, peripheral skin temperature that can be elevated to closely resemble core temperature is indicative of vascular flow to the extremities, which in turn can evoke a relaxation response.

In the sporting arena, thermal BFB has shown promise, especially when coupled with EDA. The integration of mental practice with BFB was believed to facilitate the level of congruence between cognitions and emotions ameliorating the negative effects associated with the stress of performing.

Thermal BFB has also demonstrated utility when working with athletes in extreme climate conditions. The body's natural reaction in extreme cold is to maintain core body temperature, often at the expense of the extremities. Extreme heat however, can present unparalleled challenges which can quickly result in excessive fatigue, HR

Electrode	Location/Sites	Impedence	Reference	Electrolyte
AG/AgCL	Arms, Legs, Chest Must cross midline	<5000ohms	Ulnar	Not Required

Figure 16.5 HR recording recommendations.

decreased cognitive capacity, and cardiovascular stress. Thermal BFB is a promising technique for vasoreuglation and may yield performance benefits for athletes in extreme conditions (Lehrer, Woolfolk, and Sime, 2007).

Heart rate (HR) and heart rate variability (HRV)

Heart rate (HR) reflects autonomic regulation in the cardiovascular system and is perhaps the easiest and most reliable physiological modality to measure. The dynamic nature of the heart permits the monitoring and evaluation of changes in the sympathetic and parasympathetic nervous systems that occur as a result of physical, emotional, and psychological stress (see Figure 16.5 for recording recommendations; Berntson *et al.*, 1997).

Information on HR variability (HRV) has proven useful for understanding the sequential aspects of workload and attentional direction which can be used to optimize both the mental and physical preparatory set of the athlete and in turn can be useful for better understanding important information about the mental and physical degradation of the athlete pre, during, and post performance and training. The extent by which HRV can be adversely impacted by emotional and cognitive stress is equaled by the effects of HRV training which can help maintain the delicate balance of the autonomic nervous system (Lehrer *et al.*, 2007). When HRV becomes erratic or overly restricted, the composure required for performing many complex motor skills becomes compromised (Lehrer *et al.*, 2007).

Heart rate and its variability are susceptible to change not only during physical activity but such changes are equally effected by modulation in mental activity. Research has indicated the associated CNS activity evident in HRV correlates with changes in emotional arousal and suppression, physical mobility and even cortical activation, as represented by the increased synchronization of cortical activation and the heart rate patterns (McCraty *et al.*, 1999) with significant implications for performance enhancement (Lehrer *et al.*, 2000).

Psychophysiological Recording Devices

The field of psychophysiology and biofeedback has exploded in recent years and as a result, the researcher and practitioner have a number of options to consider when selecting their equipment. The growth in the marketplace has resulted in a number of significant advancements, including precision and reliability of signal quality, ease of participant preparation, portability, signal processing, post data analysis, and the depth and breadth of software applications. Despite the positive advancements, "caveat emptor"! More than ever, the consumer must be aware of the claims and promises put forth.

In a recent article, Slawecki (2009) wrote passionately about the distinctions between laboratory based equipment and biofeedback equipment and the threats to the legitimacy of biofeedback equipment. A greater implication of this article however, are the criteria to consider when distinguishing between legitimate biofeedback equipment from that which is not. Slawecki's (2009) criteria include:

Legitimate biofeedback:

1. Biofeedback devices utilize well-understood technologies to sense quantifiable physiological parameters.
2. This information is directly manifested to the individual who, at all times, is "in the driver's seat."
3. The individual, under their own conscious will, changes the physiological state until the sensors indicate the parameters are in some improved or more acceptable range.

Nonbiofeedback:

1. Nonbiofeedback devices can utilize unconventional sensing technologies whose output is not medically recognized as a valid reflection of physiological state.
2. They may require a practitioner or intermediary who translates the results to the individual and directs them accordingly: the individual is not in the driver's seat!
3. In most cases, the "feedback" treatment is not internally generated by the individual, but arises from an external source: electromagnetic frequencies imparted directly to the individual or into water or some other substance to be ingested by the individual.
4. Various combinations exist: some technologies use EEG patterns as the physiological input to their proprietary computer software, but the output is, again, some sort of electromagnetic or "information" signal that is externally imparted to the individual.

The aforementioned criteria can be useful when searching for the most appropriate equipment depending on application. Figures 16.6 and 16.7 are intended to provide a resource of the most frequently used and recommended devices for research and applied purposes. It is important to note that the inclusion or exclusion of a device is not in any way an endorsement or censure of a product nor reflect the efficacy or utility of a device. This list is simply designed to act as an example reference for the reader to seek additional information.

Equipment	Sensors	Channels	Sampling Rate	Compatibility	Wireless	Frequency Range
Biopac						
MP100	ECG, EEG, EMG, EOG, EGG, ERS, SC, Temp, ERP	16	2048	PC, MAC		DC-5000hz
MP150		16	2048	PC, MAC		DC-5000hz
MP36R		4	2048	PC, MAC		DC-5000hz
BioHarness	ECG, Resp, SC		250	PC, MAC	✓	DC-5000hz
PsychLab	ECG, EEG, EMG, EOG, EGG, ERS, SC, Temp, ERP, BVP, Resp	Multiple devices w/ 1, 2, 4, 8, 16, 20, or 32	2048	PC		0.01–200Hz
Grass Technologies						
Model 15LT Bipolar	EEG, EMG, EOG, SC, ECG	16	2048	PC		0.01–1000Hz
Model 15 Neurodata	EEG, EMG, PSG, ERP	32		PC		0.01–1000Hz
Neuroscan	EEG, ERP	Full Map		PC		DC-1000hz

Figure 16.6 Examples of psychophysiological systems for research.

Equipment	Sensors	Channels	Sampling Rate	Compatibility	Wireless	Frequency Range	Feedback
Mind Media							
Nexus-4	BVP, EKG, SC, EEG, EMG, Temp, Resp	4	1024	PC, MAC	✓	DC – 450 Hz	Vis/Aud
Nexus-10		10	2048	PC, MAC	✓	DC – 800 Hz	Vis/Aud
Nexus-16		16	2048	PC, MAC	✓	DC – 1000 Hz	Vis/Aud
Nexus-32		32	2048	PC, MAC	✓	DC – 800 Hz	Vis/Aud
EEG-Trainer	EEG, SC, HR	4	256	PC, MAC	✓	0.5–100 Hz	Vis/Aud
BrainMaster							
Atlantis	EEG, AUX	2, 4	256		✓		Vib/Aud
Thought Technology							
FlexComp Infiniti	BVP, EKG, SC, EEG, EMG, Temp, Resp	10	2048	PC	✓	DC – 512 Hz	Vis/Aud
ProComp Infiniti		8	2048	PC	✓	DC – 512 Hz	Vis/Aud
ProComp5 Infiniti		5	2048	PC	✓	DC – 512 Hz	Vis/Aud
ProComp2 Infiniti		2	256	PC	✓	DC – 512 Hz	Vis/Aud
MyoTrac	SEMG	2	2048		✓	20–500 Hz	LED/Aud

Note: Other systems designed for at-home training not listed in this chart is the HeartMath emWave and the StressEraser.

Figure 16.7 Examples psychophysiological systems for practice.

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17

Future Directions in Applied Psychophysiology
Skills Not Pills

Richard Harvey and Erik Peper

> *Psychophysiology is at the crossroads of several disciplines, each with preferred models, paradigms, and measures. Unlike physiology with its focus on mechanism and structure or cardiology with its focus on clinical status, psychophysiology historically was driven by paradigms derived from psychology, often treating physiological parameters as if they were observable behaviors. The early psychophysiologists, defined by their use of the polygraph, applied the polygraph to "transform" unobservable psychological or mental processes into measurable physiological variables. (Porges, 2007, p. 2).*

Overview

The near term future of Applied Psychophysiology includes incorporating practices that utilize the latest wireless sensor-technology for providing feedback through a portable device such as a smart-phone, and in the longer term evolving into a profession that performs primary treatment services, such as addressing attentional deficits or stress-related symptoms, as well as performance enhancement services such as optimizing human potentials (e.g. enhancing states of consciousness or, athletic performance). Whereas applied psychophysiology practitioners use instruments when transforming physiological variables into observable concomitants of psychological processes (Porges, 2007), future practitioners will also model self-regulation skills for their clients, using themselves as instruments of change who can directly empathize with the progress of their clients.

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The field of Applied Psychophysiology ranges across many diverse domains of inquiry. In a broad sense and, depending on who is engaged in the discussion, the field of Applied Psychophysiology may focus more on physiological processes or, psychological processes. Examples of research focused on physiological processes occur in fields such as: Behavioral Medicine, Sports Medicine, Sleep Medicine, Pain Medicine, Stress Medicine, Attention Disorder Medicine, Substance Use and Abuse Medicine, Phobia and Anxiety Medicine, as well as fields such as PsychoNeuro-Immunology and PsychoNeuroEndocrinology, PsychoOncology, PsychoSomatic Medicine; and, research focused on psychological processes occur in fields such as: Psychotherapy including Cognitive-Behavioral Therapy, Family and Relationship Therapy, Psychoanalytic Therapy and Psychodynamic Therapy (see Ai *et al.*, 2010; Baglioni *et al.*, 2010; Diamond and Fagundes, 2010; Leutgeb *et al.*, 2010; Meuret, Ford, and Ritz, 2010; Posadzki and Parekh, 2009; Zhongguo, 2009).

The future of Applied Psychophysiology includes examining links with fields investigating holistic human potentials such as: Sports Psychology including athletic and somatic movement performance enhancement; Consciousness Studies including meditation, spiritual enlightenment and sensory enhancement; Entertainment Studies including electronic recreation and gaming; Sexuality Studies; Intelligence Studies including artistic, intellectual, emotional and social intelligences; and, even Confinement Studies including space flight, submarine duty, industrial mining and, prisons (see Bezrukikh and Komkova, 2010; Cooke *et al.*, 2010; de Manzano *et al.*, 2010; Kustubayeva, 2010; Schneider *et al.*,2010; van den Hurk *et al.*, 2010; Yannakakis, Martínez, and Jhala, 2010; Yule, Woo, and Brotto, 2010). Whether improving sports performance or fixing a strained muscle, Medical (pharmaceutical) and Applied Psychophysiological (nonpharmaceutical) approaches are available.

This chapter presents a rational of why bio- and neurofeedback practices have significant promise in three important domains: treating illnesses that are caused by or aggravated by stress, depression, anxiety and unhealthy life patterns by advancing holistic views of Applied Psychophysiology; incorporating technological advances into bio- and neurofeedback practice and, building conceptual models of psychophysiological health and healing. To better understand the field of Applied Psychophysiology, some definition of terms is useful, as follows: The terms "biofeedback" or "neurofeedback" refer to a set of techniques for monitoring physiology using instruments (as well as "experienced observation"), and then selectively feeding back that information to a "trainee." The term "trainee" refers to a person learning a set of skills within the context of an Applied Psychophysiology training session. In this chapter, the term "biofeedback" more broadly refers to feedback training techniques relating to peripheral nervous system processes, such as feeding back information about skin temperature, skin conductance, muscle tension, respiration rate, heart rate and other peripheral measures, even though central processes influence peripheral systems. While the term "neurofeedback" more broadly refers to feedback training techniques relating to central nervous system processes, such as feeding back information about brainwave activity and other measures of neuronal activity, even though peripheral processes influence central system processes.

Treating Illnesses that are Caused or Aggravated by Stress, Depression, Anxiety, and Unhealthy Life Patterns[1]

The majority of diseases in the industrialized first world countries are illnesses that are caused or aggravated by stress, depression, anxiety, and unhealthy life patterns (Cohen, Tyrrell, and Smith, 1992; Figueira and Ouakinin, 2008). Most of physician visits are for symptoms for which there is no known organic cause (Katon and Walker, 1998; Kahn *et al.*, 2003; Kroenke and Mangelsdorff, 1989) as shown in Figure 17.1.

A physician's role today typically includes identifying or, ruling out life threatening and organic causes of symptoms for which there may be successful treatments. When the exact causality of an illness is unknown, the physician may still prescribe medication to ameliorate symptoms of discomfort. Because the average physician

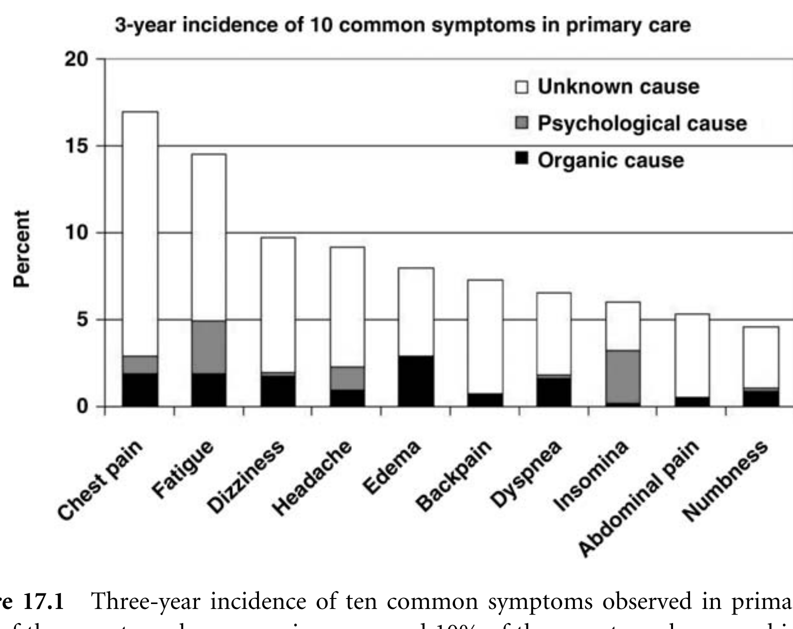

Figure 17.1 Three-year incidence of ten common symptoms observed in primary care. 16% of the symptoms have organic causes and 10% of the symptoms have psychic causes while 74% of the symptoms have unknown causes. Most likely, the symptoms are a manifestation of stress, anxiety and depression.
Source: Graph drawn from the original data in Kroenke and Mangelsdorff (1989).

[1] Adapted from: Peper, E., Harvey, R., Takabayashi, N., and Hughes, P. (2009). How to do clinical biofeedback in psychosomatic medicine: An illustrative brief therapy example for self-regulation. *Japanese Journal of Biofeedback Research.·36* (2), 1–16.

visits is between 17 and 22 minutes, there is usually not enough time to explore the personal and lifestyle factors that contribute to an illness (National Ambulatory Medical Care Survey, 1998; Mechanic *et al.*, 2001; Geraghty *et al.*, 2008). It takes significantly less time to prescribe medication to lower hypertension than it does to teach the client a set of lifestyle skills which may take twenty or more hour-long sessions to learn (Dusek *et al.*, 2008). In a modern world where people are on call 24 hours a day, 7 days a week (a "24/7" lifestyle), and where both patient and physician education has been influenced by pharmaceutical companies, patients demand quick solutions to their problems. Medication appears to be a perfect solution since getting a prescription affirms that the problem is outside the patient's mental or emotional control, and that the problem is due mainly to a dysfunctioning biological system. As a result, clients and patients begin to believe they have no responsibility for their health, and thus remain unaware of how their own thoughts, emotions, behaviors, and stress-responses contribute to the development and maintenance of the illness.

Many unexplained disorders can be successfully treated with a variety of self-control treatment strategies such as autogenic training, progressive relaxation, mindfulness training, psychotherapy, stress management techniques, diet and lifestyle modifications, and biofeedback (Carlson and Hoyle, 1993; Luthe, 1969; Linden, 1994; Lehrer *et al.*, 2007; Kabat-Zinn, 2003; Grossman *et al.*, 2004; Schwartz and Andrasik, 2004; Yucha and Montgomery, 2008). For example, heart disease has been reversed through a combination of diet, exercise, breathing and meditation (Ornish *et al.*, 1990; van Dixhoorn and White, 2005); abdominal pain in children ("belly ache" kids) has been successfully treated through heart rate variability training (Humphreys and Gevirtz, 2000; Sowder *et al.*, 2005; Shapiro *et al.*, 2006); hypertension has been reversed through a combination of relaxation, hand and feet warming, slow respiration and emotional awareness and lifestyle change (Fahrion *et al.*, 1986; Linden and Moseley, 2006); type 2 diabetes has been successfully reversed through diet, exercise and stress reduction (McGinnis *et al.*, 2005); tension and migraine headaches have been successfully treated with biofeedback (Andrasik, 2007), etc. Many of the very successful approaches were based upon an integrated/holistic approach that utilized a variety of complementary and alternative health practices. Beyond the domain of treating symptoms using bio- and neurofeedback practices as an alternative to pharmaceutical treatments, the field of Applied Psychophysiology has a future in developing, advancing and promoting "holistic" or "whole-person" practices.

Holistic Whole-Person Views in Applied Psychophysiology

The field of applied psychophysiology broadly allows for transforming the physiological and psychological processes that are unobservable to be observable, allowing the invisible to be visible, the unfelt to be felt, the unknown to be known, the un-mastered to be mastered, the undocumented to be documented and, the uncontrolled to be controlled. In addition to documenting psychophysiological reactions, the power of psychophysiology is in learning about, changing, and then mastering physiological patterns. Biofeedback or neurofeedback methods are a subset of Applied Psychophysiology in which participants learn voluntary control over their own physiological and psychological processes.

The concept of exerting control over practically simultaneous psychological (mind) and physiological (body) processes is based upon the underlying premise that every part of a psychological and physiological system are in constant communication, continuously affecting each other (Green and Green, 1977). The future of Applied Psychophysiology includes implementing new practices that emphasize the links between psychological (mind), physiological (body) systems and social/ecological systems. In clinical practice this means incorporating a holistic systems perspective taking into account “whole-person” contexts of biological, psychological, social and environmental factors that relate to a trainee, instead of merely treating a set of symptoms.

Paradoxically, as technology becomes more sophisticated, practitioners may focus more on interacting with technology and less on interacting with a trainee. Part of the explanation for the shift in interaction is that instruction in biofeedback and neurofeedback methods is often more narrowly focused on in-depth training with equipment rather than on teaching skills in client or patient interaction. Ironically, one of the main reasons that clients and patients adopt Complementary and Alternative Medicine (CAM) is that CAM practitioners tend to spend more time getting to know the whole person compared to Allopathic Medicine providers who only have time to quickly treat a set of symptoms using medications. Clinical practice of Applied Psychophysiology should not drift into the medical model of focusing on technology at the expense of the client or patient. Remember the most common quality that unifies CAM practice is a caring attitude and the amount of time spent with the client. Said in a plain way, the patient or client experience should include tender loving care (TLC). Patients need to feel cared for and understood. Underlying the future of biofeedback is the continued incorporation and awareness of TLC that reflects the “nonbillable” aspect of most successful treatments. Future practitioners in Applied Psychophysiology should remember to keep the client or patient at the center of their training goals.

The following are some key points about the future of a holistic view of Applied Psychophysiology.

1. “Improving” skills with biofeedback versus “fixing” symptoms with medications

(a) In comparison to Allopathic Medical (pharmaceutical) approaches, Applied Psychophysiological approaches depend on working together in learning ways to control symptoms through skill acquisition and mastery, which takes much more time than just taking a pill. Like learning to play the violin, “the art is the practice.” The power of bio/neurofeedback provides hope that change is possible, which translates into motivation for trainees to continue their behavioral practice. Biofeedback training is more analogous to learning a sport or musical instrument which involves goal setting, individual adaptation of teaching and learning strategies, motivation by the trainee and the teacher, specific skill mastery, home practice, generalization of skill. In many cases, the mastery process also covertly evokes and develops increased autonomy, self-confidence, and self-esteem because they achieved the goal themselves unlike reducing the symptoms by medication. Because feedback techniques are focused on SKILL learning, not PILL taking, the challenge for most biofeedback practitioners is that training and skill mastery takes time, so efficacy of a technique is often tied to the amount of time a trainee has to put into the practice of the skills.

The field of Applied Psychophysiology today includes relatively time-efficient techniques for training a set of self-regulation skills and, the future will include additional improvements in time-efficient training techniques. Ironically, the biofeedback principle of immediate feedback and reinforcement is the "fast" part of the overall process of gradually, and sometimes slowly taking the time to learn and practice a skill. Feedback helps demonstrate for the trainee that some initial learning has occurred; however, skill mastery requires time, practice and more practice. The future of Applied Psychophysiology includes refining biofeedback and neurofeedback techniques to better address the broad "fix-it" and "improve-it" categories of needs, with Applied Psychophysiological principles and practices built around a process of growth and learning that comes with time and practice.

(b) Today, some of Applied Psychophysiology research and implementation focuses on developing techniques for using new technology during feedback, instead of focusing on techniques for practicing a skill after a new technology training session. To be successful, a trainee must integrate any learned skills into their daily lives. This implies that successful training protocol depend upon teaching role rehearsal as well as transferring skills into daily life so that the skills are automatically performed. Practitioners will need to integrate behavioral strategies to facilitate transfer of learning using shaping and appropriate reinforcements.[2] Fortunately, portable biofeedback devices and smart-phone applications (apps) will be used to monitor and remind trainees to practice the skills which were initially acquired during a training session. The smart-phone apps will also monitor and report when and where the person has practiced the skills.

(c) Practitioners need to recognize that health and wellness practices are embedded within a system that includes the trainee, his/her social connections to family, friends and co-workers, as well as his/her physical or natural environment (ecology). Thus knowledge and skills related to family therapy and communication skills needs

[2] Resources for strategies to have clients practice skills outside the office are the books, Watson, D.L. and Tharp, R.G. (2006). *Self-Directed behavior*. Wadsworth Publishing and Peper, E., Gibney, K.H., and Holt, C. (2002). *Make Health Happen: training yourself to create wellness.* Dubuque, IA: Kendall-Hunt.

be incorporated into the biofeedback skill mastery program to facilitate clinical success.[3] For example, a useful clinical concept is to ask questions such as: "What role does the disorder play for the person, the family and their social setting or how is the symptom beneficial from an evolutionary perspective?" Successful biofeedback training sessions not only teaches a trainee how to master personal health habits, the training also teaches the trainee to achieve benefits without having symptoms. The future will include an ongoing integration of other complementary clinical approaches such as mindfulness meditation, autogenic training, behavioral analysis and family therapy. For example, applied psychophysiological monitoring can be used to identify the physiological change that is linked to a behavior and then precursors to this behavior that can be interrupted thus changing the "chained" reaction pattern. Disrupting a "chained" reaction pattern is an approach has been successfully applied to the treatment of epilepsy (Dahl and Lundrgen, 2005).

(d) The intrinsic component of biofeedback training is usually the use of technology and software, however, training must be balanced by "holistic caring." Clinical success is dependent on the interaction of many factors which include a caring and positive intent of the trainer, as well as a belief that the trainee can be successful in achieving the educational/clinical goal. One way to apply a holistic caring attitude during training includes changing how practitioners think of a trainee. For example, rather than labeling a person as a "client" or "patient" which risks of "medicalizing" or "pathologizing" the context of learning that occurs during the training session as well as biasing the interaction in a direction of only fixing and treating a specific set of symptoms or enhancing and improving a specific set of skills, practitioners should think in terms of a person in training. The future of applied psychophysiology focuses upon learning and training to allow the individual to reach their optimum health and performance.

2. Optimizing the processes of placebo, imagery and attribution

(a) Applied psychophysiology training will complement and augment the power and value of the placebo and reduce the nocebo effect which evoke unspecified processes that promote or inhibit the self-healing processes of the body. Embedded within a biofeedback or neurofeedback training session are placebo or nocebo components. Thus, the practitioner needs to optimize the placebo factors (and minimize nocebo factors) that may influence skill acquisition and clinical outcome. Feedback shows to the trainee that a change has occurred which builds an attribution and interpretation of hope. And hope in many cases is one of the potent factor of the placebo response. In addition, the recent mirror neuron research

[3] A very useful resource on problem solving from a system's perspective are the books, Haley, J. (1991). *Problem-Solving Therapy, Second Edition.* Jossey-Bass, and Patterson, J., Williams, L., Edwards, T.M., and Grauf-Grounds, C. (2009). *Essential Skills in Family Therapy, Second Edition: From the First Interview to Termination.* New York: Guilford Press.

suggest that practitioners who themselves have mastered some of the biofeedback and neurofeedback skills covertly, through imitation by the client, communicate a sense that skill learning is possible. Many of the early successful biofeedback pioneers have demonstrated control their physiology, such as Elmer Green, Steve Fahrion who each learned and mastered control over peripheral body temperature or, Erik Peper demonstrating control of EEG and SEMG signals. When practitioners can demonstrate self-regulation skills, clinical training outcomes are more successful.

(b) Applied psychophysiology can facilitate changing dysfunctional beliefs and attribution patterns to more functional beliefs and attribution patterns. For example, Wilson and Peper (2011) point out three dysfunctional patterns that are addressed during biofeedback sessions. Those patterns are labeled: (1) "Learned helplessness" where hopeless interpretations lead to being "frozen," unable to control the situation, followed by a shift to feeling empowerment when biofeedback demonstrates for the person that control is possible; (2) "Lazy Boy" syndrome, where the person can only relax during the training session, but not in other situations such as on the playing field, at home or at work, followed by skill generalization and role playing to integrate the self-regulation skill outside of the clinical session; and, (3) "Lack of Will Power" where the person withdraws from the hard work required for addressing their situation, modified by developing awareness of reinforcing behaviors as well as finding meaning from mastering the self-regulation skills. Future Applied Psychophysiological research will include identifying functional aspects of training including motivational aspects related to positive interpretations of attributions, role rehearsal and skill generalization.

3. Holistic therapies: Functional versus structural skill generalization

(a) The future biofeedback or neurofeedback training approaches may include somatic feedback such as practiced in the field of somatics (Criswell, 1995). For example, Feldenkrais (1949), an early pioneer in "noninstrumented" biofeedback (without using a polygraph) suggested that thinking of a problem such as paralysis in structural terms limits the therapeutic outcome possibilities, to the point that a patient will never attempt to regain functional use of their limb. In contrast, the field of Applied Psychophysiology will continue developing functional outcome measures. For example, Wilson and Peper (2011) suggest taking a holistic view of therapy, making a major goal of therapy to raise hope by exploring possibilities and having fun during a training session.

(b) Future research and clinical practice must grapple with the questions related to defining measures of health. For example, does the field of Applied Psychophysiology aim to have measures of success tied to some level of "average pathology" or, instead aim for "optimum" functioning of the whole person? Because much of evidence-based medicine relies on databases of information to understand what "normal" is among any population of client or patient, it is highly likely that "optimum health" appears as an outlier and, therefore may be interpreted as "abnormal" from the standpoint of a statistical database. Large databases of information allow for comparing individuals to a normative group, however normative does not always mean "healthy" in that normative databases may reflect a bias towards pathology (e.g. Berkson's Bias, Berkson, 1946). To make the point, the field of Applied Psychophysiology should build into to comparative databases examples of optimum outcomes, because restoring individuals to normative function may not be optimal.

Technological Advances and Applied Psychophysiology

Portable devices

(a) The future of bio/neurofeedback will be the use of small portable equipment to monitor and provide feedback in the office and at home as well as using physiological feedback as a gaming tool. Technology will increasingly utilize unobtrusive and/or wireless sensors (Becher *et al.*, 2010). For example, Poh, McDuff, and Picard (2010) recently described a system for monitoring "cardiac pulse rate extracted from videos recorded by a basic webcam to an FDA-approved finger blood volume pulse (BVP)," allowing a wireless and passive method for providing feedback about physiological states. Similarly, Holopainen, Galbiati, and Voutilainen (2007) described a framework for developing a "wireless sensor gateway" using the IEEE 802.15.4 standard ("ZigBee" standard). Their test-case included monitoring a variety of physiological functions such as heart rate, and provide a visual feedback signal via a wrist monitor (Holopainen, Galbiati, and Voutilainen, 2007). Whether for using a smart-phone or some other wireless device, the future of Applied Psychophysiology will include initially monitoring heart generated signals as cardiac measures provide a large signal to work with. For example, Leijdekkers and Valerie (2006) suggest using smart-phones connected to ECG sensors for cardiac rehabilitation patients. Kizakevich (2009) describes a feedback system using wireless measurement of symptoms attributed to post-traumatic stress disorder (PTSD).

(b) Feedback from a variety of devices can be overt or covert and, cost and portability are issues that are no longer science fiction. However, technology will continue to shrink and change, seducing practitioners away from client centered interactions. For example, it is currently possible to monitor heart rate and heart rate variability (HRV) unobtrusively from a distance, by measuring subtle changes in facial color that occur with each heart beat contraction, causing the face to flush (Poh, McDuff, and Picard, 2010). Newly emerging technologies can monitor these facial changes even though it is beneath our own awareness (Poh, McDuff, and Picard, 2010). The new technologies will take biofeedback practice in various directions. It is now possible to train clients and patients using noncontact monitoring tools that can detect instantaneous subtle biological changes and, with the appropriate software can provide feedback to the person. Another example includes miniaturization technologies that make economical and portable devices available for people to integrate into their smartphones for monitoring behavior and provide feedback. The future of Applied Psychophysiology in the former example includes developing training protocols to use new technologies; and, in the later example, to create the software and the feedback signals that the person will use to learn a new skill. Following are sample statements based on hypothetical clinical scenarios:

- "Just as the doctor prescribed taking medication about every four hours, my biofeedback therapist prescribed looking at my smart-phone about every hour. The software of the smartphone's camera measured my heart rate and identified my emotion from my facial features. After five seconds, my emotion of anger and frustration was identified and the text asked, "What are you angry about? Is the anger worth it and, are you willing to let it go? Now take control and let go." The text changed into a visual graphic and coached me to slow my breathing while a color analysis of the blood pulsing through my face tracked my heart rate. I continued practicing slower breathing to re-establish enhanced heart rate variability. I felt quieter and more at peace. After a few minutes I went back to work."
- "I sat down on the special biofeedback chair in front of a 3-D display. Instantly, my biological neuro-patterns and eye movement patterns were compared against my own baseline as well as a comparative database. Then the training started with a goal of attaining passive attention. As I achieved the correct biological balance, the display changed and I found myself in a stressful situation. The 3-D display then helped me observe my healthy physiological patterns despite the reminders of the stressful situation."
- "My watch and earphone have become my somatic and EEG sensors that each monitor my physiology. When too much theta occurs, the auditory feedback increases to alert me; when I become to tense, the music in the earphone shifts to a melodious pattern that the software and identified as inducing more relaxation."
- "Playing my computer games, a keystroke analysis sensor measured how rapidly I pressed the keyboard and inferred corresponding emotions associated with the keyboard pattern. I learned to control and master my impulsive behavior, typing with less force than before."

Conceptual Modeling

In order to frame the discussion of where the field of Applied Psycholphysiology is going in terms of Stress-Medicine and Holistic Therapies, as well as Human Potential Enhancement, a description of future Conceptual Modeling is useful. For example, it is possible to build on theories such as Hardiness Theory that provides a framework for understanding how clients and patients grow from bio- and neurofeedback experiences. Hardiness theory suggests that: people can learn from their training rather than expect someone else to "fix-it" and develop an attitude of "challenge"; people can influence their experiences and develop an attitude of control over their skills; and, people can engage in ongoing growth rather than withdrawing and develop an attitude of commitment. In relation to an Applied Psychophysiological training session, people learn from the challenge of acquiring a new skill, develop control and mastery over a set of skills and, commit to further development as their symptoms become "fixed" or their skills "improve." Applied Psychophysiology research and theory will head in directions of reducing the need for Pharmacological treatments, as well as increase the application of feedback techniques for improving Human Potential (e.g. Physical, Intellectual, Emotional and Spiritual Growth) as people become hardy as a result of bio- and neurofeedback training.

Instruction and marketing in the field of applied psychophysiology

(a) Instruction in Applied Psychophysiology could reflect a progressively more advanced set of skills, similar to training in Nursing. The current blueprint for the Biofeedback Certification International Alliance (BCIA) specifies a minimum level of competencies for certification in three areas of biofeedback, neurofeedback and pelvic floor feedback techniques that have a few levels such as entry level, academic level and technician level. A progressively more advanced set of skills and commensurate designations, similar to fields such as nursing, would lend credibility to practitioners in the field Applied Psychophysiology as they move into providing primary treatment or human potential/enhancement services.

(b) The future of Applied Psychophysiology will depend on developing a wide variety of venues for instruction, along with a wider variety of methods for marketing. For example, popular dissemination of psychophysiological practices is possible through social media networks (such as YouTube™ or Facebook™). Furthermore, as technology becomes even more portable, affordable and accessible in the form of games, there is an opportunity for more people to practice techniques of self-regulation. Designing guidelines for industry, such as a white paper related to standards for appropriate feedback techniques during remote or wireless interactive gaming, would benefit not only the gaming industry, but also the field of Applied Psychophysiology. When considered in an even broader sense, the electronic gaming industry may also be considered a developer and disseminator of feedback technology. Othmer (2010) comments that the future of Applied Psychophysiology includes motivating and educating the public about healthier ways of using gaming technology such as the Nintendo Wii™ or the Mindflex™ games toward the goal of practicing self-regulation skills. Whatever future models of psychophyiological interaction describe central and peripheral communication, achieving some clinical outcome or some behavioral skill requires practice, rehearsal and generalization outside of the clinic.

(c) Anais Nin (1969) wrote "We don't see things as they are: We see them as we are." The quote suggests that there are many theoretical perspectives that guide instruction and clinical training, that guide client and patient interactions, and that guide theory and research in the field of Applied Psychophysiology. The future of the field of Applied Psychophysiology includes integrating biofeedback and neurofeedback techniques that focus on a) treating symptoms relating to medical conditions, as well as b) enhancing cognitive and physical performance. Many scholars such as Maddi *et al.* (2010); Peper, Harvey, and Takabayashi (2009); and, Wilson and Peper (2011) have suggested that psychological processes of interpretation and attribution influence how well or how poorly individuals copes with various life circumstances, whether those circumstances relate to fixing problems or improving performance. There future in the field of Applied Psychophysiology is bright as practitioners begin integrating what they know with other fields of health and wellness.

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