Contributing Authors and Editors

Curtis Cripe received a Ph.D. and M.A. from Northcentral University in Health Psychology and Behavioral Medicine, and B.S. and M.E. in Aerospace Engineering from Cal-Poly Tech. His professional and academic background spans several disciplines that include aerospace engineering, neuroengineering, software development, addiction recovery, psychophysiology, psychology, brain injury, and child neurodevelopment.
Curtis's technical career includes participating as a senior systems engineer for JPL for NASA's deep space research missions including the first Mars landing and the first mission to Mercury, Venus, Jupiter, Saturn, Neptune and Uranus. Additionally, Curtis led software development teams for several DOD projects including technical and management efforts of a multi-site, multi-state program utilizing unique Internet management/Telemedicine brain training delivery systems. He neuroengineered an integrated cognitive rehabilitation/development/neurotherapy training programs for adult/adolescent brain recovery, and brain development for autistic/developmentally-delayed children. These programs assist families with children with learning disabilities, autism, and other developmental delays; as well as adults with depression, anxiety, substance abuse, and head injuries. Curtis has authored 3 peer-reviewed papers, 2 chapters in field-related books, is a lifetime member of the Golden Key International Honor Society. He is a Certified Neurotherapy Instructor, Certified Peak Performance Instructor, and INPP instructor for brain development.

Professor Barbara J. Crowe has been Director of Music Therapy at Arizona State University since 1981 having held a similar position at Indiana University-Purdue University at Fort Wayne from 1977-1981. Professor Crowe holds a Bachelor's degree (1973) and Master's degree (1977) in music therapy from Michigan State University. She has served The National Association for Music Therapy (NAMT) and The American Music Therapy Association (AMTA) in many ways. She was NAMT vice president from 1988-1990, President of the National Association for Music Therapy from 1990-1992 and served as Chair of the Transition Task Force on Educational and Clinical Training. Professor Crowe's research interests include the historical antecedents of modern music therapy and the theoretical foundations of music therapy practice. Publications include the articles in *Journal of Music Therapy, Music Therapy Perspectives,* and *The Arts in Psychotherapy,* book chapters in Music: Physician for Times to Come and Inside Music Therapy: Client Experiences. She is also author of the book *Music and Soulmaking: Toward a New Theory of Music Therapy* (2004). Professor Crowe was the editor and contributor to Best Practice in Music Therapy for Adults, Adolescents, and Children with Mental Disorders.

Peter Ducharme, MSW LICSW is a licensed clinical social worker in the Department of Psychiatry at Boston Children's Hospital. Mr. Ducharme received his Masters of Social Work at Boston College and completed his clinical training at Boston Children's Hospital in their outpatient and inpatient psychiatric services. His research focuses on developing and integrating active biofeedback technologies into psychotherapies with children and adolescents struggling with issues of anger, dysregulated behavior and impulse control. Mr. Ducharme has served as the Principal Investigator of three prospective clinical trials to evaluate the feasibility and clinical outcomes of incorporating these technologies within an anger control cognitive behavioral therapy intervention. He also has experience coordinating and providing psychotherapy for a National Institute of Mental Health (NIMH) multisite clinical trial comparing Cognitive Behavior Therapy to a Psychodynamic Supportive Therapy to treat children and adolescents with clinical depression in the context of a co-morbid chronic medical illness.

Susan Imholz is a scholar and clinician whose interests include the history of technology, the design of clinical tools and educational technologies. Her work has been supported by the National Science Foundation, Bill & Melinda Gates Foundation, and MacArthur Foundation. She obtained a B.A degree from Antioch College in art and psychology (1978), and became a member of the Menninger Children's Hospital staff from1978-1980 in Topeka, KS. She received a M.A. in Expressive Therapy from Lesley College (1983), then joined Seymour Papert's research group at MIT's Media Lab, and earned a Ph.D. in 1993 for her work "The computer as a projective medium: A descriptive analysis of children's use of Videworks for learning styles". Susan is the former Associate Director of the Institute for Learning Technologies at Teachers College/Columbia University, and has held additional teaching posts at Fordham University and Pepperdine University. She serves as a

consultant to public and private schools, as well as nonprofits advising on curriculum development initiatives, and technology resource development.

Dr. Rollin McCraty is the Executive Vice President and director of research at the Institute of Heart Math, and has been with IHM since its inception in 1991. He worked with founder Doc Childre to formulate the organization's research goals and create its Scientific Advisory Board. He holds degrees in Technology (1983), Radiational Physics (1995), and Health Sciences (1999) from the University of Nebraska. McCraty is a Fellow of the American Institute of Stress, holds memberships with the International Neurocardiology Network, American Autonomic Society, Pavlovian Society and Association for Applied Psychophysiology and Biofeedback and is an adjunct professor at Claremont Graduate University. He and his research team regularly participate in collaborative studies with other U.S. and international scientific, medical and educational institutions. Dr. McCraty is an internationally recognized authority on heart-rate variability, heart-rhythm coherence and the effects of positive and negative emotions on human psychophysiology.

Esther Ratner is a former Senior Lecturer at the University of South Australia where she was also Program Director of Industrial Design at various times during her thirteen years there. She was Associate Professor in the Industrial Design program at Arizona State University and Associate Director of the School of Design. Prior to her academic career she held the position of Product and Industrial Design Supervisor for Kellwood Company (a Fortune 500™ corporation). Esther holds a BFA in multi-media from Washington University and an MFA in industrial design from the University of Michigan. She has been a member of IDSA (Industrial Designers Society of America) and the DIA (Design Institute of Australia). Ms. Ratner has made presentations and publications on her creative teaching projects at numerous educator's conferences internationally including Portugal, Great Britain and Australia. An article on her teaching collaboration with Barbara Crowe was published by Music Therapy Perspectives in 2012.

Judy Sachter, graduated with a B.F.A. in Painting and Art History from the University of Colorado (1970). She worked as a freelance artist until 1975 when she became a certified K-12 Art Specialist and taught high school art in Oregon (1975-78). In 1981 she joined the Computer Graphics Research Group (CGRG) teaching 3-D computer animation classes while completing her M.A. in Art Education at the Ohio State University (1984). Her graduate work focused on the integration of art, technology and learning. She joined Seymour Papert's research group at MIT's Media Lab in 1985; her ground breaking dissertation on spatial cognition, gender differences and learning styles with 5th graders, is titled "Kids in Space" and earned her a Ph.D. in Media Arts and Sciences in 1990. While at IBM from 1990-2007 Judy's work varied greatly in focus from developing avatars, speech recognition and facial animation systems to technical strategy and marketing of advanced graphics workstations. As a technical consultant in the Entertainment Industry she managed partnerships and relationships with vendors, researchers, and engineers, and consistently found interest in facilitating and enabling disparate groups of individuals to collaborate in new ways.

PSYCHOLOGY'S NEW DESIGN SCIENCE: THEORY AND RESEARCH

SUSAN IMHOLZ AND JUDY SACHTER EDITORS

PSYCHOLOGY'S NEW DESIGN SCIENCE: THEORY AND RESEARCH

SUSAN IMHOLZ AND JUDY SACHTER EDITORS

First published in 2014 in Champaign, Illinois, USA
by Common Ground Publishing LLC
as part of the On Design book series

Library of Congress Cataloging-in-Publication Data

Author Last Name, Author First Name, Middle Initial.
Title of Book / by Author Name
p. cm.
ISBN 978-1-61229-477-3 (pbk: alk. Paper) –ISBN 978-1-61229-478-0 (pdf)
Insert CIP Data Here

Table of Contents

Preface

Terms and Scope

Clinical psychology is ready to launch a robust design science as an extension of its theories, skills, and treatments. Our book brings together research and theory from across the field of psychology, hard sciences, and art to explain and display the promise of such an endeavor. Psychology's new design science has roots in several lines of inquiry that have been ongoing since the mid 1950s and is the true synthesis of knowledge across several divisions of psychology and psychiatry as well as bridging core principles of art and design.

Not until the current decade could we say that clinicians were ready, willing, and able to consider themselves *designers* of therapeutic environments which might compete with and compliment the 50 minute therapy hour. This is due in large part to the infusion of technology into our lives and advances in thinking about mind/brain/body synergies. Contrary to the notion that technology is the driver of projects, prototypes, and products described in the following chapters, it is more accurate to say that present opportunities for shaping innovation in clinical practice and personal growth are the by-product of two decades of creative exploration of new media by artists and engineers beyond the field of psychology and mental health. Above all, perhaps it is the artificially imposed limits on brain development and the falling away of the distinction between thought and feeling that persisted during most of the 20th century in academia that has catalyzed the search for new metaphors and language for health and healing, drawing interdisciplinary influences closer. We address both theory and the design of tools that enhance people's expressive abilities, which also harbor benefits to health and personal growth.

As psychologists, psychiatrists and clinicians begin to fully engage with technical developers as equal partners, their values and humanizing influence may have extraordinary consequences for the future. Media technology has bypassed clinical and counseling professionals because clinicians' value human interaction above all else as the healing medium of intervention, and because they lack exposure to electronic media and computer science in their graduate training. There is more than one possible technological future—design that is informed by deep knowledge of human development along with engineering expertise is a relatively new concept. Its truest expression is presently found in the learning

sciences, in small pockets. The following chapters showcase pioneering examples of how this design paradigm is taking root in psychology.

The world is complex, and it will take synthesizing findings, theories and approaches across different fields to arrive at innovative solutions for advancing new modes of clinical practice. There are many points of origin from which one could begin an exploration of this subject. Establishing historical lines of inquiry that have been influential in guiding psychology toward embracing technology as an extension of its skills and knowledge seems a good place to start. Identifying organizational structures impeding or facilitating change is also a worthy subject. There is a lot to consider, all of which cannot be addressed fully only summarized in this text. *Our goal is to provide the reader with a sketch of psychology's emerging design culture and offer specific design principles for its advancement.*

Introduction

> Innovation as a 'result' depends on a judgment made by an actor, designer, user, public body….with the 'action of innovating' the designers must objectively mobilize – i.e., think up, express, defend, and promote – operations, reasoning, risk-taking and resources
>
> - Le Masson, Hatchuel & Weil [1]

Our book is an opening salvo on a topic that deserves much more attention: How will clinical and counseling professionals appropriate technology as an extension of their expertise? What support systems are in place to sustain exploration? Where else might they find inspiration? We focus on three areas that appear to be significant instigators of change and innovation--they include:

- The expansion of design science and design thinking as a field of study, and its role in assisting innovation across all domains;
- The synthesis of expressive therapies and new research in biophysiology and brain science as evolving fields of clinical practice, along with the burgeoning field of media psychology;
- The work of researchers and innovators in psychology who are pioneers in the use of media technology for mental health and healing. Our contributing authors represent different strands of clinical science, and provide us with examples of what the future might look like as clinical intermediary architecture evolves.

1. The Expansion of Design Science and Design Thinking across Domains

Design, defined as the study of the art and science of making things, now infiltrates all aspects of product development across domains. The term design science is attributed to Buckminster Fuller who defined it simply as systematic design.[2] Design science can be thought of as the epistemology of production and manufacturing—in other words reflection upon the process and aesthetics of

making things. In our book, the term is used to denote a new horizon for the clinical arts. The emergence of design thinking among clinicians signals a growing awareness that the context and availability of therapeutic arts do not meet societal needs, as well as the desire to integrate more complex models of practice that reflect new knowledge. Our thesis is that changing models of mind (linear for dynamic) along with the notion of embedding clinical assessments in creative authoring tools, activities that we enjoy, or avocations that are personally meaningful, are the conceptual drivers of innovation. Sports, music, painting, or gardening are among the many options.

We ground our discussion of design science in the work of Pascal Le Masson, Armand Hatchuel, and Benoit Weil (Hatchuel, Le Masson & Weil 2005, Hatchuel & Weil 2009, Le Masson, Weil & Hatchuel 2010, Le Masson, Hatchuel & Weil 2011)[1,3,4,5] who are theoreticians and historians of design science, as well as faculty members at Mines-Paris Tech. These authors provide us with an understanding of how new research leads to innovation, including how it fails to take hold due to unfavorable management practices and economic environments. As instrumental reasoning and efficiency wind down as the guiding principles of technology's deployment in society, technological design is cultivating an appreciation for creativity as an essential attribute of design thinking and planning. Le Masson and colleagues place new emphasis on the vital role of creative design activities as instrumental to innovation. Their expertise has been shaped by over 20 years of experience in the design and manufacture of consumer products, cars, and aerospace projects. Their observation that much of future manufacturing and innovation will take place from a position of deep subject matter expertise, with little or no previous object identity as a design template, puts clinicians on equal footing with the rest of the design community. In other words, the media membrane in which we now live and work is morphing so quickly the specs or product identity of objects that are the output of innovative design methods are being constructed in the process of their making. Another way of looking at this is that our historical moment presents extraordinary opportunities for creative thinking and creative expression to enter into the product development cycle. Design reasoning, as an overarching frame of ideas about production of media tools and objects may be attractive to clinicians – who have traditionally avoided adopting technology as an extension of their knowledge and skills – because it incorporates the language of aesthetic concerns, cultural values, emotional impact, and personal meaning, thereby elevating the traditional discourse of engineering science in purely materialistic terms.

2. *The Maturation of Expressive Therapies and New Research in Biophysiology and Brain Science as Evolving Fields of Research and Clinical Influences*

New developments in biophysiology, brain, and neuroscience also confirm that activity based therapies for mental health and optimal functioning play an important role in recovery, remediation of addiction, and behavioral imbalances, as well as self-actualization and personal growth. The expressive therapies are the original architects of the use of *intermediary objects* in psychotherapy and psychotherapeutic processes. By definition, an intermediary object is any object,

work space, or medium that continues, advances, and expands upon the patient/therapist dialogue and therapeutic relationship. Patient/client drawings, paintings, music compositions, or dance have been studied by expressive arts professionals for several decades and qualify as low-tech intermediary relational objects. The maturation of this field in regard to theory and clinical practice is providing an important substrate for psychology's sprouting design science because lessons learned can be applied to the construction and use of psychotherapeutic mediating objects in all media.

3. *The Work of Researchers and Innovators*

Over the past 25 years artists, software designers, engineers, and psychotherapists have been developing an increasingly similar shared knowledge base and tool set for creating albeit different types of human learning experiences and interactions. Contributing authors in proceeding chapters provide insight into how creativity and the production of intermediary objects as therapeutic agents change hearts and minds. These investigators have led the way in the convergence of bits, atoms, and neurons in the making of unique devices and therapeutic objects with clinical benefits.

Book Structure

In quick overview, the volume is divided into three parts. Below; a summary of the main ideas presented in each section.

Part I: Psychology's New Design Science

Chapters 1-3 address the historical seeds of the use of intermediary object architecture in clinical settings; the organizational challenges for the successful creation of a design science; and finally the knowledge surplus in search of expression that is moving psychology toward its new frontier. Why spend three chapters on positioning a discussion about uses of media technology in clinical settings by referring to historical influences, epistemology, and organizational management? The root assumptions one brings to the integration of technology for clinical practices matter greatly. In setting a context for experimentation with new media, determining the values and model of mind one wants to incorporate into design methods or goals is the core work of any design process. Questioning whether sufficient organizational structures are in place to support innovation is also salient. In Part I, we also introduce two parameters of interest which have reduced the book to manageable size. The two major assumptions that we bring into focus in the first three chapters are:

- we conceive of the majority of people who are engaging in psychotherapeutic processes as active participants in their own healing and growth, who are capable of reflecting upon their own experience, and;
- we narrow the scope and discussion of intermediary object architecture considerably by only concerning ourselves with design innovations that

attend to the inclusion of a greater number of creativity issues in a therapeutic process using new technology, or novel ways of using existing media.

Part II: Theory and Research

Chapters 4 through 7 feature contributing authors who share new knowledge, and, discuss design considerations in the making of new projects, programs and devices. These activities demonstrate how intermediary objects for clinical use are serving important needs. The composite of papers represents an ontology of innovative developments at different stages of experimentation. The design experiment profiled in Chapter 4 is a starting place for collaboration between a music therapist and design engineer and their students in an academic setting; their students worked together to build prototype instruments. Chapter 5 describes the research and design of a first generation video game that is used in an inpatient psychiatric setting to help children and adolescents manage their anger. Chapters 6 and 7 showcase therapeutic tools that reflect decades of research, and traverse the boundaries of clinics and hospitals for use in multiple settings. These tools employ new models of mind and cross-disciplinary experimentation.

Part III: Summary & Synthesis

Chapter 8 reviews the scope and aims of the book, what it did and did not cover in regard to important issues that relate to our subject, the text's contribution to the field, an overview of the major design principles we advocated in the book, and future directions for study and consideration.

We have prominently featured the notion that design science should rightfully be presented in graduate school clinical training programs as a theoretical lens for understanding and assimilating technology. This is not a simple undertaking, and will require leadership from professional associations, funding sources to promote experimentation, and the willingness of clinicians to engage and think deeply about this subject. We acknowledge that there were many issues we side-stepped, including a cost-benefit analysis of technology use in healthcare settings, and technology's darker and more alienating nature. We review the role of design science and the framework Le Masson and colleagues have provided for thinking about how to structure and organize experimentation so that it results in a productive outcome, and discuss emerging design activities. In summary, we also state that we would like to do a second volume that focuses more on the arts, and innovations in the use of art and media technology in psychotherapeutic settings.

Endnotes

[1] Le Masson, P., Weil, B. & Hatchuel, A. (2010). Strategic Management of Innovation and Design. New York, NY ; Cambridge University Press p. 329.

[2] Fuller, B. (1965). "World Design Science Decade, 1965-1976". World Resources Inventory. This material can be accessed from the web at the Buckminster Fuller Institute: Http://bfi.org

[3] Hatchuel, A., LeMasson, P., Weil, B. (2005). The Development of Science-based Products: Managing by Design Spaces. *Creativity and Innovation Management*, 14, 345-54.

[4] Hatchuel, A., and Weil, B. (2009). C-K Design Theory: An Advanced Formulation. *Research in Engineering Design*, 19, 181-92.

[5] Le Masson, P., Hatchuel, A., & Weil, B. (2011). The Interplay between Creativity Issues and Design Theories: A New Perspective for Design Management. *Creativity and Innovation Management,* Vol 20, no. 4, 217-238.

Chapter 6

Neuroengineering: Brain Recovery Methods As Applied to Substance Abuse Recovery

Curtis Cripe

"In physical science the first essential step in the direction of learning any subject is to find principles of numerical reckoning and practicable methods for measuring some quality connected with it. I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be."

-Lord William Kelvin (1824-1907) [i]

[i] From "Electrical Units of Measurement", Kelvin lecture to the Institution of Civil Engineers, London, UK, in Popular Lectures and Addresses (1889), vol. 1, 80-81.

6.0 Introduction

Alcoholism and Other Drugs (AOD) abuse is a global health issue. Individuals recovering from substance abuse have a recovery course that is, at best, troubled with recurring periods of relapse and, at worst, ends in death. AOD abuse is recognized as a brain disease, subject to brain dysfunctions that affect the individual's ability to think and make well reasoned decisions, and contributes to self-awareness and self-regulation challenges. These same brain dysfunctions are known to affect behavior and contribute to the relapse cycle. However, few in-patient or out-patient treatment programs assess or treat dysfunctional neurocognitive aspects of AOD abuse.

This chapter describes an evidence-based, bio-behavioral, brain-based assessment and treatment approach. This approach addresses metacognitive shortfalls in thinking abilities, self-awareness and self-regulation due to neurocognitive deficits related to AOD abuse. The assessment and treatment programs are based upon neuroscience, neuropsychological, and neuro-engineering methods. Neuroengineering is an emerging interdisciplinary field that combines neuroscience and engineering techniques to design solutions to problems associated with neurological limitations and dysfunctions. The central goal of the neuroengineering field is to solve brain-based (neuro) related problems and provide rehabilitative solutions for nervous system conditions.

To date, our research indicates that not only is there adequate research available to develop a brain recovery program, but also that such a program, when augmented with traditional behavioral treatment programs, has a greater than 80% efficacy. This claim is supported by documented evidence indicating that after 18 months, individuals who successfully augment their conventional addiction treatments with targeted brain-based recovery models are achieving substantially higher sobriety rates that exceed 80% vs. the 20-40% typically achieved from traditional in-patient and out-patient programs.

In addition, this chapter reviews the global severity of the addiction problem and the nature of the addiction cycle. Included is a brief discussion of the prevailing theories used to perform the analysis and treatment with the focus on the necessary neuro-systems that need repairing including the role of the brain and brain-based behaviors in addiction recovery. The chapter concludes with a description of the results from a mixed-methods study of polysubstance recovering subjects (n=300).

6.1 The BrainRecovery Program Framework

Overall, a neuroengineering approach to solving brain-based behavior issues is categorized as a cognitive remediation technique that uses modern applied neuroscience methods. The general analysis and remediation methods described below have evolved and developed over the last thirty years as a practical application to many clinical problems that did not respond successfully to conventional treatment methods. The approach works with most brain based dysfunctions. The analysis approach is called NeuroCodeX®, while the remediation technique is called NeuroCoach®. The combined analysis and remediation method, when applied to substance abuse recovery, is called the BrainRecovery Program.

The BrainRecovery program was designed to accommodate multiple delivery options that range from inpatient recovery centers, private outpatient clinics, and in the privacy of one's home using our remote TeleHealth delivery format. Presently, the program is located in select inpatient recovery centers, private outpatient clinics and remotely in the client's home setting in conjunction with one of our staff. Currently our clients access us through the web site www.smartbrainsolutions.com.

We discuss the design process used in developing these methods and the study results that demonstrate the program's effectiveness when applied to a sample of subjects participating in an addiction recovery program. It is important to note that when applying the process to substance abuse recovery, the BrainRecovery Program is considered a treatment that augments traditional recovery programs by focusing on repairing neurophysiological underpinnings that anchor cognitive distortions.

The NeuroCodeX® brain analysis approach differs substantially from conventional methods. In this neuro-engineered approach, primary behavior measures are obtained using neuro-electric indicators of neuro-circuit performance. In contrast, many conventional methods *infer* neurochemical imbalances from statistically derived classifications based upon self-reported data. While the NeuroCodeX® model focuses on neuro-circuit performance, it also includes insights from conventional statistical classifications plus structural and biochemistry measures. However, the important distinction is that it includes these as secondary measures, rather than primary measures. These secondary measures are used to indicate the health status of the nervous system or possible behavioral performance limitations due to brain structural abnormalities. In this manner, the NeuroCodeX® analysis method is able to identify brain challenges that are *not* observed by strict anatomical measures obtained from MRI or CAT scans, nor strictly metabolic activity within the brain as measured by SPECT or PET scan, nor assumed to be biochemical dysfunctions based upon a client's self reporting. In short, the NeuroCodex® analysis is considered a targeted and personalized approach, based upon objective measurements of neuro-circuits of the brains functional performance.

Equally important, each NeuroCodex® report is individualized and specialized to a specific behavioral complaint that includes brain injuries, child development, substance abuse, and/or adolescent and adult regulation challenges such as depressions or anxiety. Providing measures of neuro-circuit responses can aid in the determination if the treatment should be conventionally focused or brain repair focused.

The NeuroCoach® remediation approach differs from conventional approaches as well. NeuroCoach® does not focus on pharmacological medications nor conventional psychotherapy as the primary treatment modality. Instead, it focuses on strengthening dysfunctional neuro-circuits that contribute to dysfunctional behaviors. This is accomplished using an advanced form of Cognitive Rehabilitation Training (CRT) methods in combination with techniques derived from BCI-EEG-neuro-monitoring, Biofeedback, Cognitive Neurodevelopment, and Cognitive Bias Modification (CBM).

The NeuroCoach® program is delivered through a worldwide network that consists of a gateway system, individually assigned client portals, and a

NeuroCoach® workstation. For both inpatient and outpatient programs, the NeuroCoach® workstation, consists of a computer (desktop or laptop), with an Internet connection that allows the client to access their unique remediation program remotely anywhere in the world. Each station is equipped with a copy of our propriety NeuroCoach® software and includes a neuro-monitor (hardware) that reads brain activity. Clients connect the neuro-monitor to their head using EEG-leads to use specific client training protocols derived from the NeuroCodex® evaluation. The complete program and protocols are accessed remotely through individually assigned client portals that connect directly to the gateway system.

CRT methods focus on ***strengthening*** specific areas of the brain that create our cognitive abilities; such as the ability to attend or exert self-control required to moderate behavior. Especially for those in AOD recovery, strengthening one's ability to exert self-control allows greater access to one's willpower. This then permits greater *moment-to-moment* control over unwanted impulses or desires. An individual's remediation program may include several NeuroCoach® activities as identified from their NeuroCodeX® evaluation, each addressing specific areas of the brain.

Neuro-circuit strengthening is achieved through targeted activities that are delivered typically in a game format, in combination with real time brain monitoring. Real time brain monitoring allows NeuroCoach® to directly influence the operation of the activity based upon the level of performance of the brain. Using a propriety BCI-EEG-neuro-monitoring interface, NeuroCoach® is able to instantaneously monitor neuro-circuit performance levels and then influence the difficulty level of the activity based upon the user level of brain strength or fatigue.

For example, when strengthening the attention system, the user has the ability to choose from a set of activities that range from academics (reading, math, school work) to fun computer games as a primary activity. The client will consciously engage with the activity via a NeuroCoach® computer workstation. Attention, a brain function, requires the brain to perform many sub-functions necessary to consciously perceive what is being focused on. However, these attentional sub-functions operate non-consciously in a reflexive or automatic manner, but use specific measurable neuro-circuits to perform the task. NeuroCoach® views the activity (academics or game) as a distractor that distracts the conscious mind by giving it something to focus on. NeuroCoach™ operates on the non-conscious elements required to perform such functions as shifting attention, sustaining attention, or being able to divide one's attention "in the moment".

Based upon the results of the NeuroCodex® evaluation, NeuroCoach® monitors the brain's performance integrity level of one or more aspects of the attentional subsystems while the client performs the chosen task. From a user's perspective, he or she is simply reading a book, or playing a game, but when their attention drifts to another thought, they will see the computer activity screen fade. In other words, as one's attention drifts, NeuroCoach® will immediately measure which neuro-circuit is drifting and subsequently indicate this loss of attention by 'fading' the screen. Fading occurs if one or more of the neuro-circuits being monitored falls outside the specific performance level required to properly

support the attention system. Assuming the conscious mind's intention is to maintain proper focus, this fading of the activity directly signals the attentional sub-functions to adjust in order to maintain proper focus, unconsciously. This constant unconscious feedback and attention system readjustment over time teaches the brain to properly maintain focus and strengthens the neuro-circuits involved in attention. This is much like exercising muscles for a fit body by going to the gym, but in this case for the brain.

In writing this chapter I was asked to describe the user's NeuroCoach® experience, which as one could imagine would be difficult, since my experience with the program would be different. Therefore, I've chosen to include a user experience from a client that I worked with personally using our TeleHealth program. **J.E.** :

> "… our sessions involved wires, dimmer games, and Skype calls, but overall the NeuroCoach program was very easy to use. It took a while to get the hang of connecting the electrodes to my head in the correct places, but now I can perform the necessary preparations in fewer than five minutes. I am a full-time student with a part-time job, so I appreciate the fact that our sessions are brief and to the point. I began noticing incredible changes in my behavior and mental faculties. I liken the program results to watching your hair grow. You don't notice it on a daily basis, but after a few weeks or months, the change is obvious.
>
> I didn't realize what I had lost until the BrainRecovery program helped me find it again. From my keys to my age, I seemed to lose track of just about everything. I had grown accustomed to functioning at such a low level that I was a bit insulted when it was suggested that I could return my brain to working order. I had already been doing relatively well for myself – both in school and at work.
>
> It wasn't until I began making headway (pun intended) with this program that I realized how hard I had previously been working to maintain the appearance of normalcy. Before I started working with the program, every day was a struggle – simple tasks were major events, conversations were unbearably uncomfortable, and emotions were always powerful and overwhelming.
>
> After only a few months, I have noticed a dramatic difference. Thankfully, I can now remember my name and age at the drop of a hat, but the improvement of my memory is not what I have been most pleased to notice.
>
> The difference this program has made in my ability to manage my emotions is incredible. I have never been able to remain calm in difficult situations, never been able to logically think through trying circumstances – until now. It's almost as if this program has allowed me to move from adolescence into adulthood. The program has undoubtedly helped me reverse the damage I have done to my cognitive abilities, but in addition to doing so, he has helped me reach higher levels of functioning than I thought possible.
>
> My social anxiety has decreased, my sleep has improved, and my relationships have become more meaningful. I am far more efficient when I am working, and far more relaxed when I am not. My overall quality of life is better. Far better. Quite frankly, that is what it boils down to for me. Years of therapy and a plethora of various medications do not come close to accomplishing what the program has accomplished in a short amount of time. I cannot speak highly enough of the difference this program has made in my life. "

6.2 Approach to the Design Process

I was asked to prepare the background and design criteria used to develop this specific approach to brain recovery. Admittedly, my academic and professional background, in combination with personal life events, heavily influenced the design process.

Academically, my training includes advanced degrees in two fields: Aerospace Engineering and Psychology. The engineering emphasis was in theoretical mechanics and systems engineering, mostly applied to obtaining imaging data from space, while the emphasis of the psychology degree was in Health Psychology and Behavioral Medicine. I have applied this knowledge, in combination with my engineering background to developing remediation programs for neuro-dysfunctional behaviors.

On a personal level, two significant events related to brain traumas significantly influenced the design approach. The first was my personal, accidental medically induced neuro-trauma that did not respond to conventional treatment methods. The second event was my stepdaughter's developmental issues developed as a result of premature birth and the subsequent birth traumas. Both events resulted in brain-based impairments: for me, loss of brain function; and for my stepdaughter, inhibited development. Neither sets of brain-based impairments responded to conventional skill-based or pharmaceutical based treatment modalities, thus necessitating a different approach to getting better.

I consider myself a research engineer, in which my professional career began with JPL-NASA and my work related rocket science. This work expanded to the field of neuro-engineering. Professionally, my work for NASA included space projects that imaged every planet in our solar system, landing a vehicle on Mars, and various manned missions. My professional skills were further sharpened while participating on Department of Defense projects. Using my enhanced knowledge and these experiences, I refined and redirected that knowledge to the field of psychology and neuro-engineering. I have developed brain analysis and remediation programs that address developmental delays in children and adults, and head injuries and substance abuse recovery. These programs can be delivered either in a home setting or in a multi-center clinic environment. To my satisfaction, this method has been successfully applied to many thousands of individuals over the last thirty years. The choices made in developing NeuroCodeX® and NeuroCoach® processes were based upon logical engineering

research and development methods influenced by personal experiences. It is hoped that in explaining how the process was developed, this might spark an idea or two in others in the field of applied psychology as they develop clinical applications designed to help their clients.

Scientific design processes subdivides into three segments: 1) pure research; 2) research and development; and 3) manufacturing. In general, research scientists study how nature works and focus on pure research. Engineers, on the other hand, create new things. Engineers, in general, focus on product development and manufacturing, while research engineers bridge the scientific fields by focusing on research and development of new applications. Scientists and engineers express the scientific design process differently, as they contribute their specific knowledge to the world. For example, a scientist will use the scientific method to make predictions about the world and test their forecasts. Scientists ask questions, develop experiments, and then answer their experimental question by following a prescribed scientific method. In this manner, scientists contribute knowledge about the theoretical underpinnings that explain the physical phenomena they are studying. In contrast, engineers are considered problem solvers, who use the engineering design process and problem solving method to create solutions to problems. Engineers identify specific needs, such as '***who needs what'***, '***because why'***, and then create solutions to meet those needs. There is no fine line between science and engineering, as scientists often perform engineering work, and engineers frequently apply scientific principles.

Both the scientific method and engineering design process can be segregated into a series of steps. The scientific method is linear in nature. Once a scientist begins the experiment, the experimental steps are sequenced to completion without any deviations. At the end of the experiment, the results of the experiment are analyzed and reported to others who may be interested. In contrast, the engineering design process, even though it too is logically sequenced, is not considered a linear process, but an iterative process. As the project design progresses, the results *of the step* is examined for possible improvements. At any point in the process a new or better idea may be considered and sequenced back through the system. The reintroduction of ideas allows for a continuous improvement of the design until the engineer either comes to a final solution or exhausts his resources. This chapter will discuss the steps of the engineering design process used in the development of the BrainRecovery for Addiction program.

6.3 Identifying and Establishing the Need - Severity of the Addiction Problem

The NeuroCodeX® and NeuroCoach® programs were initially developed to assist individuals with head injuries and/or assist children to overcome learning issues and developmental delays depending on their brain-based challenges. Good engineering quality assurance requires precise monitoring of the process. Therefore, results have always been closely monitored throughout the analysis and subsequent programs during multi-center deployment. This practice has been solidly in place since inception for two practical reasons: 1) quality assurance – to

assure proper delivery of the program; and 2) to provide a means to continuously improve program results.

As the centers using NeuroCoach® increased their client base, the variety of clients and their specific needs also increased. While the centers had addiction recovery individuals in the NeuroCoach® program, those individuals typically were post-recovery and had been clean and sober for several years. These clients were interested in improving their neurocognitive abilities, memory issues, and overcoming difficulties under stress. This new population in recovery was treated as if they had an acquired head injury due to AOD use and our program results indicated they responded accordingly with expected results. Due to the exceptional results, various centers began receiving referrals from addiction recovery inpatient facilities. However, these new referrals were new to recovery and their behavioral complaints were different. Even though the clients were facing similar issue as others in recovery, their lives were further complicated by the need to resist relapsing. This new need (resisting relapsing) stimulated the redesign of the current head injury program and the development of the BrainRecovery for Addiction program.

The first step in the process was to verify that the data was, in fact, identifying a new need that was not being satisfied by another program. This prompted the question: Is there really a need for a new solution that the program was not solving or had the problem already been solved? To answer the question required the identification and then establishment of the real need, as opposed to a perceived need and a subsequent determination whether the need was currently being fully satisfied. This prompted the need to address the following questions with the resultant responses.

1. Does addiction really exist as a general problem or is it limited to a small part of the population?
2. Why is it important to solve the addiction problem?
3. What problem does the BrainRecovery for Addiction program need to solve?
4. Who needs the BrainRecovery for Addiction program?

Does the problem really exist? According to the World Health Organization (WHO), the cost of the worldwide extent of AOD use is estimated at $223 billion dollars.[1, 2] The economic impact has been estimated to be as high as 6% of some country's gross domestic product. [3] Medical costs are approximated to be 300% higher for an untreated alcoholic than for a treated alcoholic[4]. Further, AOD users account for over 12% of all deaths each year. However, despite the high prevalence of AOD use, fewer than 20% of AOD users develop clinical signs of addiction, meaning the vast majority of AOD users may not seek treatment.[2] One could easily infer that addiction issues *do* exist on a worldwide level and are not limited to a small population. In fact, it is estimated that addictions affects 9% of the US population.

Why is it important to solve the problem? On a national level, according to Substance Abuse and Mental Health Services (SAMSA), AOD dependency and associated mental health disorders are among of the most severe health, economic, and social problems facing the US.[2] Drug addiction is a leading cause

of poor health and has enormous societal impact.[3,4] It is estimated that AOD affects 9% of the US population with 40% of these individuals having concurrent mental and physiological components. [3] About 70% of addicts are employed, with their addiction contributing to absenteeism, turnover costs, accidents/injuries, decreased productivity, increased insurance expenses, and workplace violence. AOD use robs companies, government, and families of millions of dollars in health care costs, rehabilitation costs, family resources, and time away from work for those who care for the AOD individual. The economic costs are not the only costs involved. Social ramifications are significant when families are split apart. AOD affects all children, spouses, parents, and other relatives. Due to the social and economic impact, it is important to contribute an application that assists those treating addiction problems. This raises additional questions as to what problem or aspect of addiction needs to be addressed. Clearly, addiction is a vast and very expensive social and economic problem and contributes to additional collateral societal issues.

What problem does the BrainRecovery for Addiction program need to solve? A literature review has shown that while *initial* experimentation with drugs of abuse is principally a voluntary behavior, continued AOD use gradually damages neural functions that eventually impact the capacity to ***exert free will.*** [4] This process ultimately turns AOD use into automatic and compulsive behaviors that consequently lead the individual into a perpetual relapse cycle. This is especially true in individuals with genetic vulnerabilities and who may suffer from chronic stress or comorbid psychiatric conditions.

Research demonstrates that addictive drugs can trigger epigenetic mechanisms that modulate gene expressions implicated in neuroplasticity.4 Briefly, when gene modulation is disrupted, neurotransmitter signaling is modified, resulting in changes in information processing in multiple neuro-circuits. This modification includes reward/antireward signals that affect executive function/control, interoception/ awareness, mood/stress reactivity, and other personality expressions.[4] Consequently, the resultant behavioral dysfunctions are observed as addictive behaviors caused by a disruption of multiple interacting brain systems. Therefore, the BrainRecovery Program needs to address brain-based issues that occur due to addictive neuro-circuits modifications. Specifically, the BrainRecovery Program needs to target neuro-circuits that contribute to reward/antireward, executive function/control, interoception/ awareness, mood/stress reactivity, and personality expressions.

Who needs the BrainRecovery for Addiction program? Until very recently, addiction treatment research has focused mainly on behavioral and personality aspects of addiction, thus restricting the prevailing insights and subsequent treatment strategies. Behavioral studies have provided a rich understanding of how inherently complex the different phenomenological experiences and struggles can be that are encountered in addiction recovery. Respectively, these studies have also provided insights into various aspects of addictive behaviors that need to be addressed during treatment. Areas to be addressed include providing information about the addictive process, personal therapeutic insights into a person's addiction, developing skills to maintain sobriety, and the ability to express self-control over impulsive behaviors.

From behavioral research, most current AOD treatment models address the various addictive behaviors by including assorted forms of psycho-education, traditional therapy, pharmacology and/or a 12-step recovery model in their programs. However, absent from the addiction treatment literature are outcome reports on addiction treatment that includes treatment focused on brain recovery or actual brain repair. Without the necessary brain repair treatment, meta-analysis outcomes on AOD treatment programs report that the average short-term abstinence rates are 21% for untreated individuals, compared to 40% for treated individuals.[5,6,7,8] Overall, these reports suggest that treated individuals achieve higher short-term remission rates than do untreated individuals. However, these figures also suggest that 60% to 80% of individuals seeking treatment fail in their quest to maintain sobriety, making the relapse rate unacceptable to many family members of recovering AOD individuals. Clearly, the BrainRecovery Program needs to enhance existing treatment programs to improve the relapse rate for those newly in recovery by providing a brain recovery solution that augments their current treatment protocols.

In summary, the answers to the four questions in this phase of the engineering design process have been addressed. Addiction issues *do* exist as a worldwide significant problem, affecting up to 12% of the worldwide population - 9% of the US population or over 27 million Americans, not to mention the toll on society in general and family members, specifically. Equally, the economic impact can be severe, up to 6% of a country's gross domestic product. Even more importantly, 60% to 80% of those who enter a treatment program currently are not successful at maintaining sobriety. Therefore, a need *does* exist to develop an application that may assist those recovering from AOD use. Further, contributing an application that aids in solving AOD issues is important not only on a family level but also on society at large. Specifically, the BrainRecovery Program would be required to target neuro-circuits that support self-control and expressions of free will. This information was critical to the next phase of the engineering design process – defining the real problem.

6.4 Setting the BrainRecovery for Addiction Program Goal

Program development began by interviewing previous recovery clients and their families to better define their experiences and struggles with recovery. There were three primary goals that needed to be achieved: 1) did the experiences of the families and those in recovery match the current research; 2) what were the common themes experienced by those in recovery that contributed to their relapse; and 3) clarifying the BrainRecovery Program goals to ensure that the program addressed the needs of those in recovery.

Almost universally, the supporting family members' common theme was their disappointment that the recovering family member had such difficulty in reintegrating back into society. Even more disappointing for the family was the recognition of their loved one prior to addiction and that individual's unmet potential was not being met even after going through an inpatient treatment program. A second theme included the frustration of the number of years it took just to determine if their loved one could maintain sobriety. A third theme was a

concern whether the condition was due to a personality issue (i.e., sickness of the soul, a physiological issue, or an un-repairable brain disease.

A series of general, open-ended questions about their relapse experiences were collected from existing and previous recovery clients. The interview process ultimately included sampling over 300 individuals in recovery known to be prone to relapse. This group consisted of numerous cases that the therapeutic community considered "recovery resistant", many of the hardest cases imaginable. The average interviewee was 33 years old, had been a polysubstance user for 17 years, with an average of 10 residential treatment program failures. The focus of the interview was to determine what the interviewee felt or believed caused their continual relapse behavior.

Several themes emerged from the interviews. The most common themes included: "my intention was to remain sober and I really want to… for some reason I don't have the ability to control my impulses"; "It's my ADD issue, but ADD medications got me here in the first place, and when I take them I relapse… I am ADD so I am F…."; "It's the stress, even little things push me over the edge"; "I don't know, it seems like I can't think" or " the idea that it is bad doesn't come to me till afterwards"; " I must be a bad person, since I know something is wrong, but I don't seem to be aware of it 'in the moment' … only later when it's too late"; and more. These common statements were distilled into categories that aligned with the brain systems and specific neuro-circuits. From a behavioral perspective, the thematic categories included:

- Lack of self-control;
- Lack of self-regulation;
- Reflective thinking ability, resiliency, and impulsive behaviors.

Accordingly, this information was integrated with how AOD use modifies specific neuro-circuits that affect behavior. It highlighted an important insight into the heart of the problem, which had not been adequately addressed by the recovery programs experienced by the study group as a whole. This newly aligned information provided the needed clarification required to target the BrainRecovery Program goals. The revised primary goal of the program was to now provide a program that aids those in recovery to avoid relapse and reintegrate as a productive individual back into society, as a way to augment conventional addiction treatment programs. This new definition was supported by experiences with previous clients, close relatives and friends.

6.5 Problem Definition and Specifying Program Requirements

As an aerospace engineering undergrad, it was impressed upon the class that 50% of the solution to any problem is to be found in the definition of the problem. Moreover, all failures to problem solving can be traced back to improperly defined problems. As I worked on spaceflight projects over the years, these two problem-solving principles proved to be true time and time again. To create a proper solution to a problem required that the problem be properly defined, otherwise the missing part of the definition would invariably create a new problem that represented a failure in the engineering design.

Consequently, ill-defined solutions are defined as lacking clarity and specificity in their goals and solution paths. In contrast, well-defined problem solutions require specific goals and clearly defined solution paths that are properly aligned with the physical reality of the problem. Both clear goals and well-defined solution paths allow for constructive abstract thinking as the designer creatively solves the problem.

Clearly defined goals give the designer a clearer picture of what the application needs to accomplish. Goals provide a means to measure the application's effectiveness by specifying what goal the program is to accomplish and intermediate problems that require solving. For the BrainRecovery Program, the general program goal was evident from the program goal description – improve the individual's relapse rate and their quality of life. However, the phenomenological data needed to be revisited to gain a more precise definition of the intermediate program goals. This produced eight key program requirements:

1. Improve the ability to maintain long-term *personal* goals in spite of distracting stimuli.
2. Improve the ability to inhibit unwanted habitual or emotional impulses.
3. Improve the ability to adapt behavioral dispositions to changing task demands.
4. Improve the ability to modify behavior in response to errors, negative feedback, or unexpected action outcomes.
5. Improve the ability to reflective thinking.
6. Improve the ability to maintain an internal sense of self.
7. Improve the ability to maintain a greater cognitive load under stress.
8. Provide the ability to monitor key brain functions under stress and provide feedback to the status of those functions

Solution paths are defined by understanding the problem's physical nature, including constraints, and what stresses are being experienced. Defining the solution pathway is not an intuitive process, even though it becomes second nature to most experienced engineers. This is due, in part, to previous application experience, but also how the engineer understands the strengths and weakness in applicable modeling theories. Specific to the BrainRecovery Program, this requires an understanding of the nature of the addictive personality, the limitation of theoretical models, where a person is in the addiction cycle, and environmental addiction triggers.

In the field of engineering and physics, solution paths are chosen by the problem's nature and by the theoretical model chosen to model its nature in order to arrive at the desired solution. In the hard science fields, choosing which mathematical and/or theoretical model to use is straightforward. Different theoretical models that model the same physical phenomena are simply describing the phenomena from different perspectives. These unique points of view give the engineer not only the ability to observe different aspects of the phenomena, but also offer the ability to use different variables that may not be seen from another perspective. For example, when using Newtonian physics to model light or gravity, the relativity aspects of the phenomena are not observable. If the problem doesn't require relativity measures, Newtonian models are

acceptable. On the other hand, if one is looking at how light is bent around the sun or a planet and the timing of when this occurs, it requires the use of Quantum physics. Both problems are dealing with light, but the solutions use different models, depending on the problem's clearly defined goal.

Likewise, in developing applications that model human behavior, the theoretical framework cannot be ignored. Many psychological theories describe the same behavior, but from different schools of thought or perspectives. However, just as in engineering, the designer should not forget that each model is describing the same physical or psychological phenomena, but highlighting different aspects from different perspectives. For example, addictive behavior from Erickson's classical conditioning theory may be described differently than from Freudian theory. Addictive behavior from a classical conditioning model does highlight many reasons behind environmental triggers, but may not provide insight or solutions to psychological wounds that may also trigger addictive behaviors.

Psychological models of mental disorders are becoming transdiagnostic[9]. This development is linked to a shift from a categorical symptom model to a dimensional perspective of mental disorders. Defining mental disorders from a dimensional perspective is bridging categorical symptom observations with the biological basis of behavior. One means that this bridge is occurring through the use of core cognitive endophenotypes. Neuroscience research is establishing fundamental cognitive endophenotypes of psychopathology that underpin many common mental dysfunctions.[10,11,12,13] These endophenotypes offer clinicians the ability to target specific cognitive dysfunctions that contribute to the mental disorder *rather than* treating symptoms.[12]

Core cognitive endophenotypes of brain-behavior models are broadening our understanding of many mental disorders by explaining the importance of unconscious schemas, motivational processes or learning and reinforcement principles, and how they relate to psychopathology.[10,11,12,13, 14 , 15] Cognitive endophenotypes are specific cognitive traits (deficits) found to underlie part of the symptoms of a mental disorder and are related to specific neurocognitive functions. These functions include memory, attention, executive functions, with well-defined neuro-circuit definitions and measures. Impulsivity is an example of a meaningful cognitive endophenotype. Impulsivity has been recognized as a core endophenotype for several disorders including ADHD and AOD use.[15] The BrainRecovery model incorporates the core cognitive endophenotypes concept as its primary theoretical framework.

Incorporating the core cognitive endophenotypes concept into the BrainRecovery model required the phenomenological data to be revisited. We needed insight into how treating therapists characterized their clients in recovery. In the needs analysis phase of the design process, data was collected from AOD treating therapists. They were asked how they characterized a person in recovery and what they thought would help them best treat their clients. In response, therapists characterized recovering individuals as intelligent, highly engaging, likeable, charming individuals, but were impulsively driven, made poor decisions, and were unreliable with poor memories. The therapists rounded out their assessments stating that the recovering addicts generally seemed unaware of themselves, others, or their surroundings. Additionally, it was noted by the

Table 1: Specific Issues Addressed by the BrainRecovery Program

ISSUE		SOLUTION PATH THEORY
Improve ability to be present and aware – Access to conscious willpower to be at choice		
1	Improve true sense Self-Efficacy by clarifying beliefs regarding one's ***current ability to function*** cognitively, perceptually, interpersonally, physically, and emotionally.	Self-Awareness Theory
2	Improve the ability to be present and self aware in the moment.	
3	Improve the sense of personal continuity across time including feelings of self with regard to community.	
4	Improve the ability to reflect on past experiences and integrate them with present events.	
Improve actions in the world – either unconscious/conscious and self - aware actions		
5	Improve processing balance between Reflexive-Emotionally Hot-Reflective Thinking Cold Systems.	Addiction Dual Process theory
6	Eliminate cognitive biases including attentional biases, memory biases, and approach/avoid biases.	
7	Improve ability to reflectively think by improving cognition, being emotional neutral, cognitive flexibility.	
8	Improve resiliency to stress.	
Improve the ability to self-navigate ones trajectory in the life		
9	Improve the ability to hold in mind the commitment to be sober as a goal.	Self-Regulation Theory
10	Improve the capacity to alter thoughts, emotions responses, and change behaviors.	
11	Improve self-control processes that regulate urges, juggle competing goals, and sustain attention.	
Improve the ability to maintain the mental Stamina to achieve Self Goals		
12	Improve Mental Stamina.	Ego Depletion Theory
13	Monitor Mental Fatigue as a relapse trigger.	
Improve the ability to accomplish task		
14	Improve cognitive load task capacity.	Cognitive load Theory
15	Improve the ability to maintain the cognitive load capacity under stress.	
Improve the ability to expand and maintain a greater world view		
16	Improve the narrowing of "consciousness" the myopic or tunnel vision effect.	Load Theory of Attention & Cognitive Control
17	Improve the ability to be cognitively accommodating ("shift gears") and be cognitively flexible.	
18	Improve attentional control.	

therapists that with only a minimum level of stress, the recovering addict would exhibit some sort of co-morbid psychopathology that separates them from society and does not allow them to integrate. Moreover, the vast majority of the therapists were convinced the issue was absolutely an attention and impulse control issue, with co-morbid psychopathologies, and nothing more.

When the phenomenological data was reexamined from a behavioral perspective, it was easy to draw a similar conclusion – these folks clearly had difficulties controlling impulses, in addition to exhibiting attentional and antisocial behaviors. However, after distilling the same information from a cognitive endophenotype perspective, the conclusion was different. The data clearly highlighted a disruption in cognition **not** attention. This included being aware and cognitively present. The data also indicated disruptions in the ability to self-regulate and exercise self-control of impulsive actions.

Cognition functions from various cognitive domains as an integrated system. These domains include, but are not limited to, arousal, perception, attention, memory, learning, thinking, mental organization, affect (feeling) and expression, plus executive functions. Addiction and neuroscience research consistently defined many brain regions and associated neuro-circuits that aligned with the cognitive endophenotype concept. More importantly, six theories collectively provided a framework that explained much of the phenomenological experiences of the addicted brain. Table 1 details the resulting targets of the BrainRecovery Program in the final problem definition.

6.6 The Nature of Addition and Related Concepts

The BrainRecovery Program assesses mental issues and disorders from a dimensional perspective, specifically from a core cognitive endophenotype framework. From this perspective, the BrainRecovery model has converged to characterize the nature of addiction as a failure in the decision-making neuro circuitry as described by the Addiction Dual-Process Theory. Equally important, the BrainRecovery model recognizes that several key areas of the brain are adversely affected when they fail to process information properly, and relapse to addictive behaviors is most likely to occur. The brain failure modes are supported by data results that are consistent with several psychological theories that comprise of Self-Awareness, Self-Regulation, Ego Depletion, Cognitive Load and Load Theory of Attention and Cognitive Control.

6.6.1 The Nature of Addiction—The Addiction Dual-Process Theory

To describe human judgments and actions, behavioral economists proposed a useful heuristic dual-process model of brain function based on two modes of operation (automatic vs. analytical).[16,17,18] The general model has been applied to many aspects of human behavior with a unique focus on psychopathologies including addictive behaviors. The general dual-process model suggests that behaviors are guided by a balance between two distinct cognitive systems: A "hot" system, a phylogenetically older emotionally based, system that is associative in nature, operating through fast automatic viscerally based processes, while a the "cold" system, a phylogenetically newer, cognition based, thinking based system, operates through slower controlled processes that are propositional or logical in nature[19,20,21]. Several researchers have presented evidence that the two systems are strongly influenced by stress and the dynamic interactions among genetic, epigenetic, developmental, and environmental factors. This shapes the structure, connectivity and function of the brain and the resulting mental landscape.[4,22]

Further, according to the addiction dual-process theory, imbalances in the interaction between the hot and cold systems result in lack of willpower that produces relapse behaviors.

Using a "hot-cold" dual-process framework, Metcalfe and Mischel[20] explained how the interaction of the two systems clarified the processes that undermine willpower and self-control. The process is described as involving two distinct interacting systems of thought and behavioral responses "hot and cold". The hot emotional system is specialized for quick emotional processing that combines with automatic, intuitive brain processes. The hot system is the basis of all emotional expressions, including fears and passions and is independent of language and logic. The hot system relies on heuristic methods to interpret experiential evidence. This includes the ability to recognize patterns from experiences, and makes associations with similar experiential cues, schema or scripts. Likewise, this non-analytic process is holistic in nature, depends on context and domain specific perceptions, thus is pragmatic, rapid, non-conscious, and automatic or reflexive in nature.

Hot emotional actions are expressed as visceral urges such as hunger, thirst, pain, AOD use, and sexual arousal. These urges are expressed either constructively or destructively. Constructively, hot expressions are often explained in terms of tacit or intuitive knowing. [23,24] According to Polanyi [25], tacit or intuitive "knowing" represents practical understanding of a topic and is akin to a gut feeling of "knowing how".

In contrast, destructive hot emotional actions are expressed impulsively, in response to externally or internally stimulated cues that produce urges requiring immediate need for satisfaction. Impulsive visceral urges are the driving force behind uncontrollable cravings, such as hunger, thirst, pain, AOD use, and sexual arousal. The key feature of this system is that once an impulsive urge engages, it presents with an immediate uncontrollable need for satisfaction. It is this need for immediate satisfaction that helps explain why some people sometimes make unhealthy choices when unchecked or loosely checked by other more rational brain systems[24], even if they "know" better.

The hot emotional system in our model is particularly sensitive to environmental cues. The hot emotional system has been shown to be highly responsive to outside stimuli, and operates under classical stimulus response principles.[26,27,28,29] Conditioned responses then form biases in cognition known as cognitive biases. These external environmental cues act as unconscious triggers. Once triggered, they are experienced as impulses, or in our case, as AOD cravings.

Three predominate sources of cognitive biases have been identified as a learned behavior: selectively capturing attention (attentional bias), positive/negative memory associations (memory bias) and approach/avoid behaviors (approach/avoid bias). Research has shown that any one or more of these biases predicts AOD use[26,27,28,29], especially in individuals with low cognitive control abilities including working memory[26,27,28,29] or poor response inhibition. Moreover, recent meta-analyses are finding that implicit cognition is a strong and reliable predictor of substance use.[26] Elimination of cognitive bias is an important element in the BrainRecovery Program. A Cognitive Bias

Modification program was implemented to address this aspect of the addiction dual-process theory.

In contrast to the hot system, the cool cognitive system specializes in complex thought. The cool system is characterized as a cognitive thinking system that engages thought processes and includes the ability to evaluate behaviors and express our will. Characteristics of the cool system include cognition, emotional neutrality, reflective, flexible, integrated, coherent, slow, episodic, and strategic. These processes depend upon language acquisition and involve the mental and cognitive faculties associated with abstract and logical thinking. The process is rule based with analytic processes and thus requires the utilization of working memory. The process is domain general and independent of context, with slow, serial operations. This is the foundation of scientific reasoning. Above all, the cool system is considered the seat of self-regulation and self-control for self-directed behaviors.[20,21,22,26] It is important to note that, reflective thinking is a mental processing state that operates iteratively. Reflective thinking continuously processes and reevaluates current information available in the moment and compares it to whatever topic is being reflected upon. In the case of maintaining sobriety, this would include evaluating and reevaluating the pros and cons of AOD use and then activating and sustaining the will to engage in required actions needed to resist AOD use. Similarly, as in the case of the hot system, this description of how the cool system operates dictates that any addiction recovery program must account for dysfunctional neuro circuits that would weaken or disrupt ones thinking abilities. A Cognitive Rehabilitation Training program was implemented to address this aspect of the addiction dual-process theory.

For those in recovery, the health of the processing integrity of both the hot and cold systems is of particular concern especially when integrating the concept of self-awareness. The study data indicates those suffering from an over active hot system or weak cold system includes, but is not necessarily limited to, anxiety, interrupted sleep or insomnia, anti-social behavior, oppositional-behaviors, borderline behaviors, and a compulsion to use. Aiding those in recovery to become more self-aware "in the moment", and quieting the hot system, while simultaneously strengthening the cold system, proved to be three of the most important markers affecting long term sobriety.

6.6.2 Failure Mode (1) Self-Awareness Theory

Self-Awareness theory is defined as the capacity to recognize the "self" objectively, while simultaneously maintaining a sense of subjectivity about the "self".[30] Moreover, individuals only become self-aware when they reflect on past experiences while maintaining a feeling of self as being distinct from the rest of the environment across time.[31,32] Self-Awareness involves incorporating an accurate sense of self-efficacy regarding one's ability to function cognitively, perceptually, interpersonally, physically, and emotionally.[31] This definition is important for our brain recovery model as it helps to clearly define the solution path and the remediation program requirements, including areas of the brain that need to be addressed.

Self-Awareness theory also makes an important distinction between being simply conscious and being self-aware. First proposed by sociologist George

Herbert Mead, consciousness is described as processing incoming environmental information without regard to self or self-knowledge.[33] Individuals not self-aware but purely conscious are able to successfully process environmental information, respond to it adaptively, *but without any regard to how they feel or what the consequences may be to their own life.*[34,35] This suggests that many of the experiences expressed in the thematic portion of our study, occurred while those in recovery were mainly conscious, but not self-aware. When reviewing the quantitative data study results, this factor is noted as a key relapse failure mode.

More practically for our model, self-awareness consists of three important measurable constructs that have been incorporated as part of the progress tracking module in the NeuroCoach® program. These constructs include metacognitive or global awareness, emergent awareness, and anticipatory awareness.[36] Metacognitive awareness is required to successfully complete a task in the context of everyday situations. It includes the awareness of the task characteristics and strategies in addition to a personal sense of self-efficacy, one's beliefs and affective states. More importantly, it includes knowing how and when one's characteristics and abilities influence the outcome of task.[36]

Emergent awareness requires self-monitoring of one's cognitive state in order to recognize errors, to self-regulate to adjust performance, and to self-evaluate to compare beliefs and perceptions with performance outcomes. Emergent awareness is defined as the ability to recognize difficulties as they occur moment-to-moment during task performance. Emergent awareness uses the brain's self-monitoring, self-regulation and self-evaluation neural systems during task performance to operate. These neural systems are constantly interacting with each other providing information to each system and adjusting based upon information received from each other. This fact requires the performance fidelity of each system to be integrous due to their interdependency. Finally, anticipatory awareness is defined as the ability to predict the effect of personal deficits on future performance, such as encountering relapse triggers.

This description of the levels of self-awareness and its constructs provided practical neuro-circuit targets required for assessing and monitoring of self-awareness. This is critical for recovery. However, while self-awareness or lack of self-awareness helps us understand one major contributing factor in relapse prevention, the Self-Awareness model only explains a portion of the experiences reported by those in recovery. To gain further insight, we turn back to the Addiction Dual-Process theory to understand what happens when a person experiences a lack of self-awareness or being present in life. This has a direct influence on the ability to remain sober.

6.6.3 Failure Mode (2) Self-Regulation

According to Bandura[37], human behavior is motivated and regulated by self-influences that are guided by the self-regulatory system. From Bandura's perspective the self-regulatory system mediates the effects of external and internal influences that allow successful completion of desired outcomes through purposive actions that are regulated by forethought. The social cognitive school of thought uses self-regulation interchangeably with the terms *willpower, self-*

discipline, or *self-control* and describes self-regulation as the ability of the self to exert control over the self .[37]

Self-regulation refers to the mental capacity to alter thoughts, emotions, and change behaviors.[37] Moreover, self-regulation relies on the brain's self-control processes that regulate urges, juggle competing goals, and sustains attention. Self-regulation allows people to make plans, choose from alternatives, control impulses, inhibit unwanted thoughts, and regulate social behavior. Self-regulation is especially important for those in recovery. The ability to express self-control, especially under times of temptation, can be the defining key ingredient that allows one to remain sober or relapse.

According to Bandura[37], self-regulation operates through three self-regulative mechanisms. These mechanisms include (1) *behaviors* - self-monitoring of one's behavior, its causes and effects; (2) *thoughts* - judgment of one's behavior in relation to personal standards and environmental circumstances; and (3) *emotional responses* - self-evaluative reactions. Bandura further stresses that self-regulation also encompasses self-efficacy which further highlights the importance of the need to be properly self-aware.

Bandura explains that intentional and purposive action is deeply rooted in how the brain represents future events. Future events are represented cognitively in the present as thoughts in the mind. These representations are then the foundation for personal motivators and regulate future behaviors, thus shaping or guiding actions, thoughts and emotional responses. What is important to note is that these representations shape the future (i.e., committed willpower, when expressed as a causal agency, actually resides and is anchored in one's conceptualized forethoughts). Furthermore, the self-regulatory system translates these forethoughts into incentives that guide all purposive actions. For those in recovery, this means that one must not only have the goal of staying sober in mind, but also the internal commitment to remain sober. More importantly, the brain must be capable of self-regulating and expressing this willful commitment. Weakness in the brain self-regulatory system will produce self-regulatory failures that promote relapse. Using the knowledge of the self-regulation system operation in conjunction with the dual-process model hot-cool system functionality, clarifies many contributing relapse factors. A good intention, with an inability for the brain to self-regulate, paves the way for relapse. Equally true, failure in maintaining a good intention, even with strong self-regulation abilities also paves the way for relapse. The next three failure modes address possible areas in the brain that contribute to intentional failure.

6.6.4 Failure Mode (3) Ego Depletion Theory

Most everyone has experienced times in their life when they were either tired or overwhelmed and simply went along with the flow. This behavior often results in decisions that are ultimately regretted. These are times when the sense of self or sense of ego is weak. These times have been shown to affect our ability to hold and execute proper intentions.[38,39]

Psychoanalytic theory defines the ego as the part of "self" that experiences and reacts to the outside world. It is this part of the self that adapts through one's intentions and sets the mediation tone between primitive drives and the demands

that society dictates, including the physical environment. It is the seat of our I-ness. When it is weak, so are our intentions. Weakness in ego strength paves the way for primitive drive expressions, lack of social adaptability, and allowing psychopathology behaviors to dominate, regardless of our good intentions or the strength of our brain processing abilities.[38,39,40,41]

Baumeister [39], in his Ego-Resource Depletion model, described how one's ego strength fluctuates depending upon cognitive effort and how it affects ones self-regulation abilities. Baumeister proposed that self-regulation, like many other cognitive domains, fatigues with extended effort. In the ego-resource depletion model, ego-resource capacities are not fixed, but fluctuate throughout the day. In this manner, the ego-depletion model casts self-regulation as an *inner* ability that relies on an *internal* resources or energy that is limited. Neuroscience studies support this concept by demonstrating that self-control is mediated by fatigue in specific brain areas involved in various aspects of behavioral regulation. Demands on self-control resources have been shown to increase behavioral impulsivity, including disinhibition and prompt myopic decision-making. Further, evidence suggests that ego depletion detrimentally affects executive function, self-control and has been found to predict AOD behaviors. From our study data, ego depletion contributes to relapse. This is based upon reports of the feeling 'brain-dead', which then promotes the need to escape this reality, and is therefore, experienced as a relapse trigger and promotes lack of self-awareness and the inability to reintegrate appropriately back into society.

6.6.5 Failure Mode (4) Cognitive Load

The Cognitive Load concept is more generally used in the field of computer science when describing the limits in a learner's information-processing ability. This concept is used in conjunction with the flow of information through the mind's processing structures and how those structures interact. These structures are comprised of working memory, long-term memory, and schemas of how they operate. In research, this concept has become a central theme for instructional design of learning systems with predominate focus on the effects of the working memory capacity. Learning system developers understand that the amount and type of information presented to the learner affects the learner's rate of learning or amount of information retained by the learner. Focusing on increasing the learning rate of computer applications has benefited our understanding of how to measure cognitive loads using neuro-electric measurements.

Similarly, in our work with developmentally delayed or learning challenged children, this concept has proven to be true. However, we noticed that cognitive load effects are more far reaching than just supporting the ability to learn. From our data, cognitive load capacity also is crucial to the child's maturation cycle, their ability to develop self-regulation abilities, to attend, focus, concentrate, and then to learn. More importantly for both children and adults, the concept of cognitive load also is apparent in task execution. We have found that low working memory capacity or its resiliency to stress contributes to high errors in task performance that result in short tempers, histrionics, avoidance, acting out behaviors and depressions. These observations are supported by research studies that report low working capacity contributes to executive dysfunctions and are

found in many psychopathological disorders involved with self-regulation dysfunctions.[44,43] In fact, several studies reveal that low working memory capacity even predicts alcohol use.[64,60,63,43] Our BrainRecovery Program model includes the measurement of cognitive load capacity under different stress conditions that simulate stress conditions in a real world situation.

6.6.6 Failure Mode (5) Load Theory of Attention and Cognitive Control

Load Theory of Attention and Cognitive Control provides a framework for understanding the cognitive mechanism involved in ego depletion. These mechanisms include attention, awareness, and cognitive control. In Load Theory, perceptions are limited by the brain's capacity to receive and process information (the brain has a sensory component to working memory)[42]. Moreover, perception is an involuntary automatic action that occurs when the brain is conscious. More importantly, it cannot be shut down at will. This is an ongoing process that occurs regardless if one is self-aware. For those treating individuals in recovery, this information is important because those in recovery are susceptible to environmental cues and it cannot be assumed those cues can simply be ignored by "willing" them away. This detail about how perception works helps explain why those in an inpatient recovery facility are able to have a bit more control while in an inpatient setting, but lack control once they leave the inpatient facility. The lack of environmental cues reduces the craving triggers during their stay. Additionally, this understanding also further reinforces the need to reduce cognitive biases towards AOD use as outlined in the Addiction Dual Process theory.

Of extreme importance to our Brain Recovery model is what occurs when the brain is under task. Load Theory also states that perceptual capacity too fluctuates from moment to moment, based upon the level of difficulty of the task at hand. Load Theory divides tasks into four separate categories, based upon high or low loading factors and which system is being utilized under task - the perceptual system or the self-control system. Load Theory asserts tasks with high perceptual loads (or attention) are not just fully engaging, but also fully use the brains perceptual capacity. Examples of such tasks are passionate intellectual pursuits in the arts or sciences, fully engaging problems, being fully absorbed in reading a book or even playing video games. The commonality with these tasks is that the outside world appears to disappear, along with our inner dialogs, due to the perceptual capacity of being fully engaged. The result is that irrelevant internal or external stimuli are automatically screened out. Hence, irrelevant distractors are not within the brain's conscious awareness. In Load Theory, this phenomenon is called attentional blindness, since the brain literally does not perceive anything other than its current focus. Surprisingly, this phenomenon is not an attention deficit issue, as heard from many parents and adults. It is however, how the attention system works with highly engaging and absorbing tasks. The brain simply becomes fully absorbed or lost in the task at hand.

In contrast, low perceptual tasks do not require usage of all the brain's available perceptual capacity. As a consequence, this allows the brain to receive or process more information than necessary for the task at hand. Since perception acts in an involuntary manner, the brain will continue to attend to information

(external or internal) until its perceptual capacity is filled. This automatic process allows irrelevant information to involuntarily be available for processing. Examples of this process is observed as mind wandering or being distracted by folks just passing by. Again, it is important to note, this is not an attentional issue, but how the attention and perceptual system operates under low perceptual loads. The extent, to which unwanted, irrelevant, distractors are prevented from gaining control over behavior, depends on the operations of the brain's cognitive control functions.

The brain's cognitive control system has a limited functional capacity too. As in the perceptual capacity, cognitive control capacity is defined as either low or high and is a function of working memory operations. High cognitive loading tasks include tasks that use virtually all of the available cognitive control resources, while low cognitive load tasks are tasks that use only a portion of the cognitive control resources. Research has demonstrated that participants under high cognitive load have impaired self-regulation. For example, dieters under high cognitive load exhibit unrestrained eating in comparison with participants under low cognitive load.[43,44] Similarly, Muraven and colleagues[41] showed that participants who engaged in an effortful thought-suppression manipulation subsequently displayed impaired impulse control and drank more alcohol than did control participants. It was important for our Brain Recovery model to consider the brain's perceptual capacity. Perceptual capacity is dynamic and changes based upon health conditions and fatigue. The functional health and resiliency of the perceptual system is measured and monitored throughout the recovery cycle.

6.7 BrainRecovery Program Brain Targets and Specifications

Design specification details exactly what will be required of a product and how to achieve the goals before it is designed. Specifications are the performance standards that the design must meet. They are quantitative, measurable criteria that the product must satisfy. In order to be measurable and unambiguous, specifications must contain a metric, an engineering unit, and a target value. For the BrainRecovery Program this includes neuro-circuit definitions, neuro-electric measurement indices and how they interrelate.

Contemporary neuroimaging studies offer evidence that the brain is a dynamic self-organizing system.[45] This dynamic system consists of a collection of anatomically dissimilar but functionally relatable brain regions[46,47] with measurable coherent neural activity that occurs when the brain is at rest and when actively engaged.[48,49,50,51,52,53] These relationships are classified as brain connectivity. The BrainRecovery model uses three classifications of brain connectivity: structural, functional, and effective connectivity. *Structural connectivity* refers to regions of the brain that are linked anatomically by white matter tracts. *Functional connectivity* refers to brain regions that are linked by timing measurements, irrespective of whether they are directly linked anatomically. *Effective connectivity* refers to connections derived through measurements of direct causal effects that one brain region produces in another. Collectively the different kinds of brain connectivity are described as networks, designated as either structural or functional neural networks. Neural network systems have been shown to operate through a top-down and a bottom-up set of

neural mechanisms.[54] Failures in these mechanisms are implicated in contributing to cognitive impairments.

Top-down neural mechanisms are the cortical neuro-circuits that exercise cognitive control on behaviors, predominately derived through thoughts, or the cold system in dual-process theories. For example, a deficiency in top-down prefrontal functional neural mechanism is associated with impaired non-adaptive learning. [55, 56] Bottom-up neural mechanisms are the mechanisms that are subcortical driven, the hot emotional system. These mechanisms are the neural circuits that drive our passions and when dysfunctional, impulsivities. For example, increased functional connectivity (a dysfunctional connectivity) of bottom-up mesocorticolimbic structures with prefrontal regions has been associated with enhanced reactivity to AOD stimuli.[57] In alignment with dual process theory, the operation of these two networks suggests cognitive impairments and addictive behaviors may be attributed to differential functioning of brain networks with overlapping regional areas of the brain. Moreover, this alignment suggests that by examining the integration of task-related regional brain activity with known functional networks allow identification of the functional (or dysfunction) levels of specific neural mechanisms that underlie cognitive impairments.[57] This principle has been successfully applied to the NeuroCodeX® analysis in the examination of clinically relevant measures and is also used to monitor treatment progress.

The BrainRecovery targets six primary brain networks required to solve the problem outlined above. Three networks were chosen to improve mental stamina, reflective thinking abilities, self-referencing, resiliency to stress, self-regulation and three were chosen to improve self-regulatory abilities.

6.8 Creating the Final Solution

To summarize, the BrainRecovery Program goal was distilled as follows: To provide a program that aids those in recovery to avoid relapse and return back into society, and that augments conventional addiction treatment programs. Both the program goal and problem definition use a dimensional diagnostic framework. During the phenomenological data collection and review phases, two measures of program effectiveness were identified that included a relapse rate and a measure of quality of life. The problem definition design phase classified eight key program requirements, including addressing disruptions in cognition that directed the solution path. The solution path analysis resulted in modeling the nature of addiction using the addiction dual process theory. This phase of the design process identified 5 key brain failure modes, 18 key problems that need to be addressed along with 18 key areas of the brain that require monitoring during recovery, with the resultant discovery of being substantially closer to solving the problem at hand. The next task was to create the program by finding solutions to the problems previously defined.

This next phase of the design process should inherently create multiple solutions that will solve the problem, which would lead to the determination of the appropriate solution. The final step resulted in the development of a working prototype. For this phase, the data collected during the program goal and problem

definition phases was applied. While this phase generated several iterations, the program continues to be improved as new information is learned about the brain.

Strict behavioral psycho-educational and pharmacological solution approaches were immediately ruled out based upon several criteria: 1) they are currently included in the conventional addiction treatment approach; 2) neither approach directly affect repair of brain circuits; 3) the phenomenological data didn't support a pharmacological solution based upon one of two commonly voiced themes by those in recovery – a)" I threw the medications away because I didn't like how they made me feel" or b) I am a drug addict and these meds are stimulating my relapse"; and finally 4) the phenomenological data didn't support a pure behavioral solution based upon the theme - "I couldn't remember what was taught".

More importantly, this decision was based upon a comparison that makes the choice more apparent. Using a racecar analogy, assume there is a high performance racecar and a highly capable driver driving entering a race. There are at least three major domains that affect the performance and end result of the race; the car's mechanics; its fuel mixture; and, of course, the driver. If the racecar isn't mechanically sound (say has a flat tire, bad fuel injectors, or bad wiring) this will affect its racing ability, regardless of the quality of the driver or fuel that is in the tank. However, if the mechanics are superb, but the fuel mixture is off, there is an equal likelihood that the race performance will be intermittent or stall. And finally, if the driver is a novice (lacks racecar driving skills), even with excellent mechanics and superb fuel mixture, the outcome of the race may nonetheless, be adversely affected. It takes all three domains in combination to be in good running order for the best outcomes.

Conventional approaches to addiction treatment currently only address the driver (by focusing on behaviors and skills) and the fuel mixture (medications). Treatment results indicate that these treatments are only 20% to 40% successful. Therefore, logically, our efforts were focused in the direction that wasn't being addressed, the "mechanical" aspects of the problem (i.e., the brain's wiring and functional performance).

Based upon our vast experience working with clients with brain injuries and learning issues, the most obvious implementation for the BrainRecovery Program was to extend the current NeuroCodeX® and NeuroCoach® programs to incorporate the needs of the addiction community. For the NeuroCodeX® analysis, additional performance measures were added that addressed the core cognitive endophenotype models of self-awareness, self-regulation, cognitive load, self-referencing, resiliency to stress, and self-regulation.

With regard to the NeuroCoach® program, its foundation is based upon cognitive rehabilitation training methods. Cognitive rehabilitation therapy is a treatment that was originally developed at King's College in London to assist cognitively impaired individuals in order to restore normal brain function.[58] The method has been successfully applied to patients with schizophrenia, brain injuries, children and adults with ADHD, as well as cognitive deficits associated with major depressions. Over the years, the NeuroCoach® remediation program has followed CRT principles. It has now evolved to include many brain exercises that promote proper brain function. A unique addition to the CRT methodologies is the inclusion of the use of brain wave monitoring technology. In order to

strengthen and shorten treatment duration, the NeuroCoach® program incorporated brain wave monitoring technology to monitor how the brain performs while undergoing the brain exercises, giving both the therapist and client instantaneous feedback on brain performance while under task.

Traditionally, the CRT method uses repetitive drills and practice to facilitate improvements in cognitive domains that include memory, cognitive flexibility, attention and executive problem solving, without the use of brain monitoring or biofeedback assistance. The repetitive drills are regularly focused on specific skill sets that need to be *re-acquired* as opposed to the underlying neuro-circuits that need to be *repaired* to perform the skills.

Traditionally, the CRT programs can last several months to several years before long-lasting training results are observed. When traditional CRT methods were applied to a child with development delays, there was improvement in the area of the brain being trained. However, the skills often did not generalize to other cognitive functions nor promote further maturation. These two facts, in combination with a daily reminder that my stepdaughter was falling further behind her peers, prompted the need for improving the traditional CRT methodology. Our version of the CRT method evolved to include the ability to monitor neuro-circuit responses. We also took a neurodevelopment perspective and aligned the cognitive repair exercises with how core endophenotypes develop.

Over the years, working with developmentally delayed children and using the same engineering design process outlined above, the NeuroCoach® program has resulted in a set of brain based exercises that target specific areas of the brain required for brain maturation. With regard to behaviors (child or adult), two key principles were discovered in the process. First, the functional outputs of a core cognitive endophenotype developed in a specific order, and the different core cognitive endophenotypes are interrelated. Additionally, when one system was immature, related systems would be as well. This immaturity resulted in challenging behaviors at best, regardless of age. Second, each cognitive system had to perform at an age appropriate level. If not, immature behaviors would be the natural result.

For example, regardless of the age of the child, when the capacity of the auditory short-term memory did not measure to age appropriate levels, primary speech development was negatively affected. Further, the quality and fluidity of speech also was directly related to auditory capacity of the short-term memory. The greater the auditory memory capacity, the more fluid the speech, until it reached adult capacity. In addition, the capacity of the auditory system fluctuated based upon stress and the resiliency of the nervous system, and this fluctuation affected behavior. For example, when the auditory working memory system was under stress, its capacity was reduced. If the reduction was below a certain capacity level, the result was some form of acting out behavior. This was true not only with children, but also with adolescents and adults. The difference in adults and adolescents was that the behaviors were often expressed as anxiety or explosive tempers. Later, this observation was extended to include behavioral response from several other brain systems. When we applied these principles to the addiction population, we found these two principles held true for this population as well, and contribute to co-morbid diagnoses. Our study data also

highlighted that one of the consequences of AOD use is that many of the cognitive endophenotype functions lose their natural resiliency under stress. The observation coincides with expressions of co-morbid psychological behavior expressions that after treatment went away.

Based on these documented observations and recorded expressions, the NeuroCoach® program has evolved to an advanced form of CRT methodology. At this time, the program is now able to address 17 of the 18 intermediate problems that required resolution. This last intermediate problem required us to reconsider how the NeuroCoach® program was designed. Initially, intermediate problem number 6 – Eliminate *cognitive biases including attentional biases, memory biases, and approach/avoid biases,* didn't appear to require strengthening of any core cognitive endophenotypes. From our understanding, cognitive biases were associatively stored memories that were situational evoked. This assumption proved to be only partially correct. However, after revisiting the quantitative data, what we found was a non-conscious emotional response that weakened one's ability to exercise self-control in the moment when a cognitive bias cue was stimulated. This meant that problem 6 definition could have one of three solution paths: 1) reduce the strength of the associative cognitive bias memories; 2) strengthen one's self-control ability when emotionally provoked by environmental cues; or 3) provide an integrated solution that both reduces cognitive bias associations and strengthens self-control during cue reactivity times. To address this combined problem, we implemented a module based upon Cognitive Bias Modification (CBM) methods in the NeuroCoach® program that operates in conjunction with strengthening the self-control neuro circuits. The CBM methods are targeted at ***decreasing*** non-conscious automatic processes and have been found effective at altering attentional bias[59,60], memory bias[61,62], and approach/avoid bias.[63,64]

6.9 Test, Redesign and Refine the Solution

The final steps in the engineering design process consist of testing the product to determine how close the product results match the design specifications and then refining the product until the design converges to meet the design requirements. These requirements included the effectiveness of the BrainRecovery Program at reducing the relapse rate and the program's effectiveness at aiding recovering individuals' productive reintegration into society.

To determine this viability three important outcome measures were required to demonstrate positive effects. Two of these measures were a result of the problem definition phase. Answering the intervention causality question required the third measure. The outcome measures needed to reflect: 1) improvements in the rate of remaining sober, 2) positive changes in social reintegration, and 3) positive causal treatment effects resulting from the BrainRecovery intervention. Of the original 300 individuals we randomly chose 150 individuals, who completed the training program, and followed them for 18 months post treatment. The average interviewee was 33 years old, had been a polysubstance user for 17 years, with an average of 10 residential treatment program failures. The following describes the study results post treatment.

Did the treatment demonstrate improvements in the sobriety rate? At the 18-month follow up, 89% of the follow-up group maintained sobriety, 98% had transferred from sober living facilities and were maintaining their own residency. The 89% sobriety rate is a substantial improvement as compared to the 20% to 40% sobriety rate reported in the literature, indicating that the BrainRecovery Program was successful at improving the sobriety rate and did augment existing inpatient/outpatient treatment programs.

Did the treatment demonstrate positive changes in social reintegration? To answer this question pre and post measures of individual resiliency, personality, and quality of life data were examined. In addition to improvements in the sobriety rate, resiliency scores collected from the Connor-Davidson Resilience instrument indicated a significant positive pre-test and post-test changes in-group level score. Resiliency is defined as the ability to become stronger, healthier, or more successful after encountering an adverse event. From the initial collected data, group level resilience scores averaged at 49 points, which is consistent with previous PTSD and AOD studies.[65] However, post treatment group average scores made significant improvements by 32.5 points up to 81.5. These scores were now consistent with the general population. Further, an examination of pre and post quality of life phenomenological data also revealed equally significant changes.

Pre-test scores of quality of life data indicated that the group was highly dependent, not self-supporting, had difficulty with employment and/or had drop out of school, and in constant legal issues of one kind or another. In contrast, the post-test data indicated that 98% of those monitored for 18 months post treatment program reported no arrest records or new legal issues, were employed, in school or in vocational training. The positive report of no new arrest records, employment, school attendance or vocational training, in conjunction with maintaining their own residency demonstrates a positive social reintegration effect derived from the BrainRecovery Program.

Nonetheless, these measures only partially yield insights into how well the self-regulation system is responding. To gain further insights into the strength of response we examined reports from data collected from the Millon Clinical Multiaxial Inventory-III. This segment of the examination addressed two primary concerns: 1) were there significant global reductions in personality issues, including externalizing and internalizing behaviors; and 2) did the symptom changes result in clinically significant results. Rushton & Irwing's[66] General Factor of Personality (GFP) framework was used to model the GFP and the externalizing and internalizing behaviors factors. The examination documented a GFP general reduction of 42% in general harmful behaviors, 38% reduction in harmful externalizing behaviors, and 48% reduction in internalizing behaviors. These results indicate a positive treatment effect. Additionally, the second examination question used the same personality data and also indicated a significant clinical effect. Table 2 depicts the clinical significant factors along with the associated reduction in undesirable behaviors.

Did the treatment demonstrate causal treatment effects? A quasi-experimental non-equivalent dependent multivariable design was used to answer this question in conjunction with the Reliable Change Index. This design was chosen over a traditional randomized control design for clinical and ethical

Table 2: Significant Clinical Changes based upon Millon Clinical Multiaxial Inventory-III

Clinical Patterns	Clinically Significant		Symptom Reduction	Clinical Patterns	Clinically Significant		Symptom Reduction
	Pre	Post			Pre	Post	
Avoidant	Yes	No	48%	*Anxiety*	Yes	No	53%
Depressive	Yes	No	41%	*Major Depression*	Yes	No	55%
Dependent	Yes	No	46%	*Dysthymia*	Yes	No	53%
Antisocial	Yes	No	38%	*Somatoform*	Yes	No	54%
Borderline	Yes	No	42%	*Thought Disorder*	Yes	No	42%
Paranoid	Yes	No	44%	*Delusional Disorder*	Yes	No	39%

considerations. It was determined that a study that employed randomized assignment to a control group and treatment group in which all subjects are actively seeking sobriety and control over their relapse rate would not have benefited those seeking clinical help and therefore deemed unethical for the study. Therefore, a quasi-experimental method not only aimed at demonstrating causality between an intervention and an outcome result, but also supported a single group non-control experimental design was chosen.[67]

Two little used methods of demonstrating significant changes statically and clinically are Non-equivalent dependent multivariable designs and the Reliable Change Index calculation.[68,69] Non-equivalent dependent multivariable designs continue to be recommended as a preferred choice in demonstrating clinical effectiveness for many medically based treatments.[68] This scientific design uses one or more variables not subject to treatment as a control variable in order to demonstrate causal inference. The design involves the inclusion of one or more primary dependent variables along with one or more nonequivalent dependent variables and can be used with a single subject group. A nonequivalent dependent variable is defined as a control variable that acts like a control group. The variable is required to be affected in the same way by history, maturation, and other single group internal validity threats as the treatment variables. However, not so much alike that it is affected by the treatment. Both classes of dependent variables are required to assess similar constructs, in our case brain performance measures, such as the ability to recall information (dependent variable) and phonological awareness ability (nonequivalent dependent). The key that makes this method effective is that both classes of variables are influenced by similar non-treatment factors and confounds. However, only the dependent variables are exposed to an intervention (i.e. treatment addresses memory neuro circuits, but not the auditory processing circuits). After treatment, dependent variables are expected to change based upon the interventions applied (better ability to recall information). In contrast, nonequivalent dependent variables are not expected to change after treatment (no change in ability to hear sounds). Treatment effectiveness including casual inference conclusions is demonstrated by the resulting outcome comparison of the expected pattern (expected changes only with the dependent variables and little to none in the nonequivalent variables)[67,68].

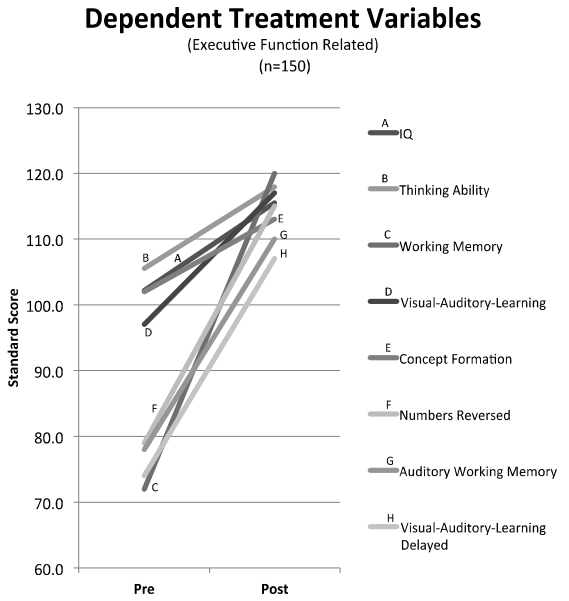

Figure 1: Treatment Dependent Measures

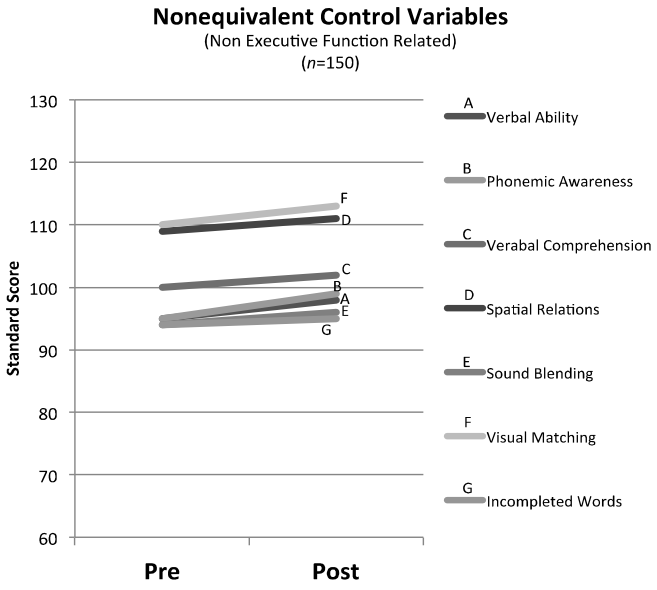

Figure 2: Nonequivalent Control Variable Measures

For our study, eight dependent measures and seven nonequivalent measures were chosen from the Woodcock Johnson Cognitive Abilities III Assessment Battery (WJIII). The WJIII is a set of intelligence tests based on the Cattell-Horn-Carroll (CHC) theory of cognitive abilities. The CHC theory provides a comprehensive framework for understanding the structure of cognitive information processing abilities in performing cognitive tasks. Dependent variables were chosen from the WJIII that are effected by executive function changes, while the nonequivalent control measures were chosen based upon sensory system measures that were not expected to change due to treatment. Figure 1 and Figure 2 depict pretest and posttest group scores. As anticipated when applying the pattern match step to the analysis, the study results demonstrated a positive pattern match for a causal inferential response to treatment, thus allowing a positive conclusion that the BrainRecovery Program treatment does positively influence the areas of the brain that are involved in executive thinking and control.

The Reliable Change Index (RCI) was developed to provide a measure of both *statistical* and *clinical* significance of changes due to a treatment. This measure is very useful as a statistical measure of category membership and can demonstrate the effectiveness of a rehabilitation program.[69] The RCI demonstrates how much, and in what direction an individual has changed, and whether those change are reliable and clinically significant. The study results were examined using a variation of the RCI that accounts for practice effects [103-106]. Statistical and clinical significance is indicated when RCI values are equal to or greater than 1.96 (the 95% confidence interval).[69,70,71,72] Table 3 depicts normalized RCI values. The RCI values were normalized by the minimum RCI value that signifies statistical and clinical significance. Values of 1 or greater signify that the treatment changes are both statistically and clinically significant. As anticipated, dependent cognitive measures met or exceeded the minimum 95% confidence interval requirement, while nonequivalent dependent variables did not.

Table 3: Treatment and Non Treatment WJIII Cognitive Abilities Variable RCI values

Treatment Variables	RCI		Non Treatment Variables	RCI
IQ	2.84		*Verbal Ability*	0.77
Thinking Ability	1.72		*Phonemic Awareness*	0.85
Working Memory	1.14		*Verbal Comprehension*	0.72
Visual Auditory Learning	1.90		*Spatial Relations*	0.41
Concept Formation	1.30		*Sound Blending*	0.59
Numbers Reversed	1.19		*Visual Matching*	0.35
Auditory Working Memory	1.87		*Incomplete Words*	0.61
Visual-Auditory-Learning Delayed	3.26			
Cognitive Efficiency	1.08			

6.10 Conclusion

The development of the BrainRecovery Program used a neuroengineering approach in order to solve brain based behavior issues. Further, the BrainRecovery Program applied to AOD recovery has consistently demonstrated through evidence-based documentation significant improvements in recovery

outcomes. A focus on strengthening self-control neuro-circuits allows greater willpower to be exercised *in the moment* over unwanted impulses or desires. The program outcomes have also demonstrated that the cognitive repair techniques used in the program, when properly applied to the areas of the brain impaired by substance abuse, allow productive reintegration into society. In this manner, the BrainRecovery Program has demonstrated that this approach can and does define brain challenges that are *not* observed by strict anatomical means nor based upon a client's self report. The BrainRecovery Program, when used in conjunction with traditional AOD therapies, has been shown to further reduce AOD behaviors, assist those in recovery to overcome relapse challenges, and aid in proper social reintegration.

Endnotes

[1] UNODC, World Drug Report 2012 (United Nations publication, Sales No. E.12.XI.1)
[2] Rehm, J, et al., J (2009). Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. *Lancet 373,* 2223–2233.
[3] Results from the 2012 National Survey on Drug Use and Health (NSDUH) H-47: Mental Health Findings.
[4] Volkow, N.D., Baler, R.D., Goldstein, R.Z., (2011). Addiction: pulling at the neural threads of social behaviors. *Neuron* 69, 599-602.
[5] Monahan S, Finney J (1996). Explaining abstinence rates following treatment for alcohol abuse. A quantitative synthesis of patient, research design, and treatment effects. *Addiction* 91: 787–805.
[6] Moyer A, Finney JW. Outcomes for untreated individuals involved in randomized trials of alcohol treatment. *Jrl Subst Abuse Treat* 2002; 23: 247–52.
[7] Miller WR, Walters ST, Bennett ME (2001). How effective is alcoholism treatment in the United States? *Jrl Stud Alcohol*, 62:211-220.
[8] Dawson DA, Goldstein RB, Grant BF (2007). Rates and correlates of relapse among individuals in remission from DSM-IV alcohol dependence: a 3-year follow-up. *Alcohol Clin Exp Res*, 31:2036-2045.
[9] Miller E, Cohen J. (2001). An integrative theory of prefrontal cortex function. *Ann Rev Neurosci*; 24: 167–202.
[10] Emmelkamp, et. al. (2014). Advancing psychotherapy and evidence-based psychological interventions. *Int. Jrl. Methods Psychiatr. Res*. 23(Suppl. 1): 58–91.
[11] Lambert M.J. (2007). What we have learned from a decade of research aimed at improving psychotherapy outcome in routine care. *Psychotherapy Research* 17(1), 1–14.
[12] Insel T., et al. (2010). Research Domain Criteria (RDoC): toward a new classification framework for research on mental disorders. *American Journal of Psychiatry*.
[13] Hofmann S.G. (2008). Cognitive processes during fear acquisition and extinction in animals and humans: implications for exposure therapy of anxiety disorders. *Clinical Psychology Review* 28, 199–210.
[14] Hofmann S.G., Sawyer A.T., Fang A., Asnaani A. (2012). Emotion dysregulation model of mood and anxiety disorders. *Depression and Anxiety* 29, 409–416.
[15] Robbins T.W., Gillan C.M., Smith D.G., de Wit S., Ersche K.D. (2011). Neurocognitive endophenotypes of impulsivity and compulsivity: towards dimensional psychiatry. *Trends in Cognitive Science* 16, 81–91.
[16] Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review 4,* 108–131.

[17] Steele, C. M., & Josephs, R. A. (1990). Alcohol myopia: Its prized and dangerous effects. *American Psychologist 45,* 921–933.
[18] Moss, A., Albery, I., (2009). A Dual-Process Model of the Alcohol–Behavior Link for Social Drinking. *Psychological Bulletin* (135), 516-530.
[19] Knight R. G., Longmore B. E. (1994). *Clinical Neuropsychology of Alcoholism*. Hove: Lawrence Erlbaum Associates Ltd.
[20] Metcalfe J., Mischel W. (1999). A hot/cool-system analysis of delay of gratification: dynamics of willpower. *Psychological Rev* 106: 3–19.
[21] Thompson, V. A. (2009). Dual-process theories: a metacognitive perspective. In Two Minds: Dual Processes and Beyond (eds J. S. B. T. Evans & K. Frankish), pp. 171–195. New York: Oxford University Press.
[22] Sullivan E. V., Rosenbloom M. J., Pfefferbaum A. (2000). Pattern of motor and cognitive deficits in detoxified alcoholic men. *Alcohol Clin Exp Res* 24: 611–613.
[23] Marcum, J. (2012). An integrated model of clinical reasoning: dual-process theory of cognition and metacognition. *Journal of Evaluation in Clinical Practice* (18) 954-961
[24] Henry, S. G. (2010). Polanyi's tacit knowing and the relevance of epistemology to clinical medicine. *Journal of Evaluation in Clinical Practice* 16, 292–297.
[25] Polanyi, M. (1966). *The Tacit Dimension*. Garden City, NY: Doubleday & Co.
[26] Rooke SE, et al. (2008). Implicit cognition and substance use: a meta-analysis. *Addict Behav.* 33:1314–1328.
[27] Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health Psychology Review*, *2*, 111–137.
[28] Stacy, A. W., Ames, S. L., & Knowlton, B. (2004). Neurologically plausible distinctions in cognition relevant to drug use etiology and prevention. *Substance Use and Misuse 39*, 1571–1623.
[29] Hofmann, W., Gschwendner, T., Friese, M., Wiers, R. W., & Schmitt, M. (2008). Working memory capacity and self-regulatory behavior: Toward an individual differences perspective on behavior determination by automatic versus controlled processes. *Journal of Personality and Social Psychology*, *95*, 962–977.
[30] Prigatano, G.P. & Schacter, D.L. (Eds.) (1991). Awareness of deficit after brain injury: Clinical and theoretical issues. New York: Oxford University Press.
[31] Toglia, J., & Kirk, U. (2000). Understanding awareness deficits following brain injury. *NeuroRehabilitation*, 15(1), 57-70.
[32] Barco, P.P., Crosson, B., Bolesta, M.M., Werts, D., & Stout, R. (1991). Training awareness and compensation in postacute head injury rehabilitation. In J. Kreutzer & P. Wehman (Eds.), Cognitive rehabilitation for persons with traumatic brain injury (pp. 129-146). Baltimore: Paul H. Brookes.
[33] Natsoulas, T. (1985). George Herbert Mead's conception of consciousness. *Journal for the Theory of Social Behaviour*, 15(1), 60–76.
[34] FitzGerald, M., Carton, S., O'Keeffe, F., Coen, R. & Dockree, P. (2012). Impaired self-awareness following acquired brain injury: current theory, models and anatomical understanding, *The Irish Journal of Psychology*, 33:2-3, 78-85.
[35] Carroll, E. & Coetzer, R. (2011). Identity, grief and self- awareness after traumatic brain injury, *Neuropsychological Rehabilitation: An International Journal*, 21:3, 289-305.
[36] Barco, P.P., Crosson, B., Bolesta, M.M., Werts, D., & Stout, R. (1991). Training awareness and compensation in postacute head injury rehabilitation. In J. Kreutzer & P. Wehman (Eds.), *Cognitive rehabilitation for persons with traumatic brain injury*. Baltimore: Paul H. Brookes.
[37] Bandura, A., (1991). Social Cognitive Theory of Self-Regulation. *Organizational Behavior and Human Decision Processes* 50, 248-287.

Part III: Summary & Synthesis

Chapter 8

Summary & Synthesis of Psychology's New Design Science

Susan Imholz and Judy Sachter

8.0 Scope

This text has posed big questions. We began by asking: How will clinical and counseling professionals appropriate technology as an extension of their expertise? What support systems are in place to sustain exploration? Where else might they find inspiration? In response, we have raised more questions than answers. Our goal was to provide the reader with a sketch of psychology's new design science, and offer a critical evaluation of technology's potential, acknowledging that there is not a media facilitated solution to every therapeutic modality or context. What seems certain is that if clinicians are never exposed to design science and design reasoning, they will miss opportunities to enhance the creative potential of their work for themselves and their clients.

We have joined together the notion that design science and innovation are allies and partners. Le Masson and colleagues (2010, 2011)[1,2] have given us the conceptual framework for discussing how clinicians can be competent actors of new product design. To be successful, innovators need to be armed with a theoretical understanding of design reasoning and deep knowledge of their field. Le Masson has also made clear that inexperience in product design is not, in and of itself, a barrier or disadvantage to entering the marketplace. What's important

is that entrepreneurs appreciate and value the depth of their knowledge and subject matter expertise, for this is the real currency of innovation. Clinician's have a wealth of knowledge and experience to contribute to the design of intermediary architecture that extends their expertise.

We have prominently featured the notion that design science should rightfully be presented in graduate school clinical training programs as a theoretical lens for understanding and assimilating technology.

We suggested the benefits of incorporating design reasoning and processes into clinical training programs:

- The design literature provides structure, guidance, and a long term view of how clinical architecture can evolve over time using systems thinking;
- It makes distinctions between 'innovation' and 'fixation' (retrofitting old processes and activities) and articulates the specific characteristics of what innovation oriented activity and development look like;
- Much of future product development across the fields of science and healthcare will take place from a position of deep knowledge with no previous object identity—design science offers methods for navigating these circumstances, Le Masson et al (2010) call this the 'third era of modern management'.[2]

We offered design principles for innovating clinical tools:

- Construct objects and tools that increase participation and creativity on the part of the client/patient;
- Construct objects and tools that deliver clinical expertise to a wider community of clients/patients who are living in the social world;
- Embed analytical tools in avocations and activities that are enjoyable;
- Design the new normal based upon new research instead of using labels and diagnostic categories as design parameters (individualize design goals and objectives);
- Incorporate media psychology research into design labs as foundational knowledge for building intermediary architecture.

In the future, the measure of success in forging a psychotherapeutic alliance may be judged by the superiority of the holding environment the clinician constructs for his or her patients 24/7, qualified and quantified by the patients' perception of progress toward a therapeutic goal, or real world accomplishments. Added data gathering and performance assessments are another reason to rethink how technology can be useful.

8.1 Back to the Drawing Board

Innovation in Art and Media Techology

Speaking for the editors, we regret that we were unable to include more examples of art, film, and animation uses in therapeutic settings, which are ongoing. We cited expressive therapy as being an important substrate for thinking about intermediary object architecture, then did not deliver as full a discussion of this

area as we would have liked. Therefore, we have decided to compose a second book that focuses on these approaches. There are many expressive arts therapists who are tinkering with technology, and many artists who are addressing mental health issues through the use of digital media. We feel these efforts are just as important in shaping psychology's design culture as new brain science, because they are situated in social and macroworld contexts which influence public discussion and challenge established perceptions. Furthermore, the legitimacy of how peripheral participants in any community of practice are brought to the center of its knowledge, advance new ideas, and become experts is well established. [3]

Lurking in the Shadows

We have side-stepped many thorny issues regarding our media membrane. We are swimming in a sea of technology that harbors dark forces—but they shouldn't deter us from imagining, designing, and creating a better world using technological utility. There is a level of transparency of purpose that is achieved in clearly stated design principles which helps us discern the inventive from the redundant, or malevolent. In other words, the core values and knowledge underlying object construction is revealed in its design principles. When Seymour Papert, Marvin Minksy and others at the AI Lab at MIT conceived of the programming language LOGO [4] for children in the 1960-70's it was a significant milestone for human interface design. Their insistence on applying knowledge of cognitive science and observations of children's classroom behaviors to the construction of LOGO and the floor Turtle[4] injected a new set of design parameters into discussions of educational software. This cross-disciplinary act forever changed the composition of design staffing across the industry.

If today's Technium seems devoid of humanitarian values – it's by design. The brain trust of psychological knowledge and expertise is still missing from technical design teams across industries. This is one of the reasons why we've got smart robots, smart phones, a robust tech driven military-industrial complex—but are only beginning to devise broadly distributed tech mediated healthcare solutions for the public. How does this reflect on our priorities? As mentioned in earlier chapters, advocating for media technology experimentation in the field of clinical psychology, psychiatry, and counseling professions could have far reaching effects upon the culture at large. It will open up new lines of dialogue and cross fertilization where none exist.

Cost Benefit Analysis

Peter Ducharme and colleagues briefly mentioned the perceived cost-benefit of using technology in mental health care settings in Chapter 5, and this too deserves much more attention. The authors commented that their intervention was portable, cost-effective (in terms of development expenses), readily appropriated by patients, and readily accessible to therapists without interrupting their normal therapy process. There are plenty of critics ready to mount contrary opinions citing the expense of development costs and use as being unaffordable. [5]

Compliance with the HITECH Act[6] is another issue to take into consideration when estimating costs and benefits as there are now penalties in place for violating patients' medical information privacy (HIPPA laws) which specifically address electronic media use. While these are worthy topics, they were beyond our scope.

Other Uses of Technology Set Aside

The two major assumptions that we brought into focus in the first three chapters that eliminated discussions of many redundant uses of technology in psychotherapy were:

a. we conceive of the majority of people who are engaging in psychotherapeutic processes as active participants in their own healing and growth, who are capable of reflecting upon their own experience, and;
b. we narrowed the scope and discussion of intermediary object architecture considerably by only concerning ourselves with design innovations that attend to the inclusion of a greater number of creativity issues in a therapeutic process using new technology, or novel ways of using existing media.

These tenants eliminated all uses of administrative scheduling platforms, use of telephone (including Skype), and electronic forms of tests and measures, and set us on a course of exploration toward innovation. Le Masson and colleagues reinforced our beliefs that invention requires creative skill building, and the willingness to abandon established ways of doing things.

8.2 Contribution to the Field of Clinical Professionals

Overall, the book's contribution to the field lies in its breadth. We have set this discussion in historical context, a "where have we been" and "where are we going" narrative that points to the lineage of thought that has led to design thinking as a natural extension of clinical knowledge. We've dismissed the notion that clinical practice needs to discard established expertise and give up the therapy hour to embrace new media.

We invited a group of accomplished authors and writers who are examining how their model of mind and approach to health and healing can be amplified by new research, technology, and tools to share their work. Each has emphasized design reasoning as a new frontier for clinical sciences in their own way, and each has included the client as a participant in the design enterprise. Together, they have enlarged the scope of the book considerably. Pioneering research by Cripe and McCraty & Atkinson clearly shows how new knowledge leads to reconceptualizing existing models of treatment. In addition they have given the field of clinical science a better understanding of the bio-physiology of health and illness, along with new terminology for thinking about how to design therapeutic interventions and intermediary object architecture.

Contributing authors have provided very specific direction on how to organize and manage exploratory design projects by their example. In Chapter 4, Crowe & Ratner showcase first steps on the path of experimentation. In Chapter 5, Ducharme and colleagues demonstrate an initial collaboration project among several clinicians that resulted in a prototype of a videogame that entrains, strengthens, and rewires neural pathways to assist patients in regulating their emotions. In Chapter 6, Dr. Cripe, an experienced product designer of clinical solutions, gives us a template for approaching the design process that can be applied to multiple media contexts and prototyping projects. His research with recovering substance abuse patients also provides us with new conceptual models for constructing treatment protocols. In Chapter 7, McCraty & Atkinson feature ground breaking research in our understanding of mind/brain/heart connectivity, which was the basis for the design of the emWave heart monitor.

Ontological Design Perspective

All chapters and authors employ multiple systems of thought for problem solving, which is a hallmark of design reasoning. With time, the more seasoned clinical designers (Cripe and McCraty & Atkinson) show increasing complexity in their thinking and design process. This ability to synthesize more data sources and weave in additional theories in iterative product development cycles is precisely what Le Masson's C-K design method (Chapter 3) is all about. Test, redesign and refine, as Cripe puts it in Chapter 6, emphasizes ongoing knowledge development is key to customizing the NeuroCodeX® and NeuroCoach® platforms to serve new populations. In the product design literature innovation often occurs in one of two ways; 1) rogue actors who disrupt the marketplace with technical innovation, or by bridging two domains of knowledge expressed in a device or tool with no predecessors, 2) established companies or products which create new distribution systems, i.e., Netflix 'over the top' delivery of streaming content direct to consumers, by-passing cable fee structures. Dr. Cripe is the text book portrait of the rogue actor and entrepreneur, capable of linking two communities of practice—engineering, and cognitive science—who was a dissatisfied consumer in search of treatments that didn't exist. Therefore, he created his own. We have suggested that innovation in clinical design is more likely to emerge from seasoned, motivated clinician-practioners, where expertise resides, for the foreseeable future.

In Chapter 5, Ducharme and colleagues note their experimentation was driven by need as well; the authors were responding to a call from the American Academy of Child and Adolescent Psychiatry (AACAP) for an end to the use of restraints in hospital settings.[7] AACAP did not specify the methods of development for new interventions to prevent and treat aggressive behavior in children in hospitals and in the social world, only that behaviorally based interventions need better engage children and adolescents in training them to control their anger in real life interactions. What Ducharme shows quite clearly in RAGE-Control, is that their game (along with instructor led body-centered exercises) is providing patients with a new type of experience, not found in traditional psychotherapy, and not found in educational settings, using the language of neuroscience. From a design perspective, it's important to stress

what patients are being taught through the use of RAGE-Control is that they are capable of mastering their emotions in a demonstrable way, using concepts heretofore not available to them in any learning context. Whether or not labile emotions are caused by faulty brain circuitry and genetic endowment, or, the result of early imprinting on dysfunctional parents and caregivers, the good news is that neuro-engineering has the power to re-wire the brain.

In Chapter 7, McCraty and Atkinson provide us with in depth investigations of how self-monitoring analytical tools (Freeze-Framer and emWave biometric systems) can be effective in a number of ways with multiple subjects; a) healthy adult individuals and improved cognitive performance on tasks, b) the long term effects of psychophysiological coherence, as learned behavior, on cognitive performance, c) high school students exposed to a HeartMath intervention (entrainment in psychophysiological coherence) before year end exams, which lowered test anxiety. As with the Menninger Hospitals, new theories of mind which hypothesize that mental illness is not as fixed as previously thought, continue to expand and refine treatment methods. Expanding the stage upon which therapeutic interventions can be enacted to include the social world—homes and communities—is the final frontier of mental health care access.

Innovation Metabolisms

Strategic management of innovation and design methods is applicable to economics, sociology, the aerospace industry, and as we propose to psychology's new design science. The key feature of creating an 'innovation field' or 'I' function, according to Le Masson et al (2010)[2], is to conceive of it as a management objective that can be built into organizational activities, as opposed to thinking of it as a quixotic phenomenon of chance. The authors warn that front-end exploratory activities that comprise the 'I' field must be as well thought out and well documented as the research and design product development phases to be meaningful. Innovation fields give birth to a number of rival or complementary projects; in the Chapter 3 clinical case study for example, rival projects might be parallel explorations of what type of interface best supports Hevesi's trance therapy protocol. Learning from experience, the clinical design team may find that elements of an innovation field for a first product development cycle then migrate to a rule-based design phase in the next cycle—giving rise to new 'I' field activities.

Le Masson raises interesting questions about whether 'object impermanence' as a design problem is just a phase or whether the pace of technical change will become stable once again.[8] For instance, the authors note we've been in a constant state of fluidity regarding the design of cell phones since the year 2000, although touch screen phone displays have maintained their grip on the industry for 6-years, features and accessories keep multiplying. As it relates to creating an innovation metabolism for the field of mental health we have not asked the question, will there be a better time for clinical practitioners to jump in? We advise now is the perfect time, and venture capital seems to agree.[9] The climate for obtaining seed funding for healthcare start-ups is extremely favorable as of late 2013, which may indicate a confluence of forces are at work to release clinical expertise into the marketplace in ways that will give consumers and the

general public an opportunity to be the storehouse of information about their own well being.

8.3 Emerging Design Activities

What can psychology learn from design science? Primarily that the integration of technology into clinical practices is not simply a mapping function. Innovation is not as easy as adding extra readings to the graduate curriculum. What's needed are opportunities for experimentation. If every mental health professional association—psychologists, social workers, psychiatrists, and expressive therapists— declared 2015 the year of the media design charette, and sponsored such forums at their annual meetings, they could jump start new media initiatives. We've made the point that today science is conducted in large teams, with funding support, within larger organizational structures—i.e., NIMH, professional associations, foundations, and healthcare institutions. Without a critical mass of investigators banding together, and without leadership in academic training programs advocating for design labs, the clinical design movement will thrive, but won't have the benefit of the rich historical knowledge of psychology that resides with scholar/clinicians in academic centers.

Starting an open source software movement to expand and support mental health services to communities, peer-to-peer support groups, and establishing collaboratories for sharing data in academic centers are three recommendations we have made to catalyze innovation.

The design culture of educational technology may be a model that clinicians can learn from to establish both guidelines and a pedagogical scaffold for design activities. Not just any model will do – by reputation our exemplar is known as the Bauhaus of educational technology curriculum shops—the Columbia University Center for New Media Teaching and Learning, or CCNMTL.[10] When the center was founded in 1999 by the late Frank Moretti with the assistance of Robbie McClintock, they had the foresight to conceptualize three design templates that have endured as archetypes for designing curriculum across all Columbia University schools and colleges. Their methodology for course construction was conversational (meaning they involved long dialogues with faculty members who shaped the choice of content and materials), involved iterative design experiments, and an analysis phase that integrated student perceptions of course materials. The course templates in brief are:

- Analytical & Communication Tools: Custom calculators, graphical information systems, remote sensing techniques, for health, law, economics, and sciences;
- Multi-media Study Environments: Film, video, graphics and text based resources combined to allow students/users to; author, annotate, contribute original research to the resource, access and reconfigure video, or texts to interpret materials;
- Field/Laboratory Tools: Handheld devices and tools that can be used in field settings to capture record, and assess data in a multitude of formats.

These conceptual models were a starting place for generating curriculum modules that were refined by the needs of faculty. The CCNMTL moniker of 'Bauhaus approach' came from a particular sense of artfulness evident in their work. This aesthetic applied to the look and feel of the final product. Like Le Masson's analysis of the Bauhaus as a design method (Chapter 2) both camps share the belief that increasing creativity was a desired outcome of innovative production processes, and that new creativity issues and opportunities arise from introducing novel substrates, or building materials.

As clinical design grows, it is easy to see how useful these design models might be. The emWave neatly fits the definition of an 'analytical tool'; music therapy and art therapy tools conceived as multimedia environments for music making and artistic composition opens up new possibilities for saving and archiving client work; and peer-to-peer support systems that exist outside traditional mental healthcare institutions are fertile ground for thinking about what new field tools might look like. 'Things to think with' have been part of the educational technology lexicon for over two decades. If we contrast the practice of psychotherapy with that of education and the evolution of instructional materials and tools that have entered K-12 schools over this time, one sees a stark contrast in attitudes and readiness to adopt technology. This can be explained by theoretical differences between these domains; symbolic mediators, as a design concept, have been part of curriculum culture for over a century. Why, haven't there been a greater number of innovations in things to think with specific to psychotherapy and clinical practice? The short answer is that psychodynamic and analytical psychotherapy have been relationship-based verbal practices. These two schools of thought (Freud & Jung) have dominated private practice in American mental healthcare for most of the 20th century.

Making What's Ephemeral Concrete

The opportunity endemic to all sciences at this particular moment in time is to use new forms of data to conduct experiments, build new models, question our assumptions and the relationship between things, and to validate and extend theory.

A unique challenge for psychology's new design science is to capture and embody the etheric qualities of psychotherapeutic healing processes—particularly those clinical methods not based on cognitive behavioral models—and make them into tangible media interfaces. Distilling the essences of a century old clinical practice, and embodying them in new media is no small task, but deserves expert consideration.

We noted that the clinical literature is comprised of three dominant modes of discussion; theory which explores and defines the healing process, techniques of psychotherapy which are addressed to clinician, and case studies by both clinicians and patients reporting on their experiences of recovery. Our book offers a fourth conversation, which includes design reasoning as an established means for applying theory and research to mental health treatment.

Thinking through what a Jungian intervention looks like using film and video, what kinds of psychodramatic play and social skills training can be adapted to media platforms and venues, or how an art therapy studio can be

enhanced by mobile communication tools, are all experiments awaiting serious consideration in clinical training programs. Several categories of psychotherapy exist as amorphous art forms, by which we mean a craft that is practiced with theory as a primary tool in one-on-one settings. The healing relationship between patient and therapist has been characterized as; a) creation of an emotional atmosphere and holding environment which allows the patient to feel and experience a sense of well being, b) the quality of transference between client and healer, c) a rite of passage, d) symptom relief from anxiety, or other ills, e) imparting social problem solving, and coping skills. When therapeutic environments that fulfill these functions are more broadly distributed throughout the culture, we will have a healthier society.

Most importantly, our message is about the value and spirit of cross disciplinary collaboration. This is a mindset. We do not want our readers who are clinicians to think they need a degree in electrical engineering; nor do designers need to acquire a clinical degree to move the bar on technology integration. All of the tools you need are at your fingertips. In Chapter 4, Professors Crowe (music therapist) and Ratner (industrial designer) describe the immediate benefits to students and clients when recounting their initial experiment. Simple is a good place to start.

Ultimately we're advocating for change to impact a difficult, multifaceted problem—our mental healthcare system. Experience has taught us that complex problems require lots of talented people working together to resolve them. The mental health budget line is the 'short straw' in every imaginable lottery; beginning at the federal level of government on down, to municipal spending. Injecting creativity and creative thinking into all aspects of the system, conceptualization of treatments, the design of delivery systems, and clinical training programs is one way to attack the stagnation, or 'fixation effects' of bureaucracy. In many ways, new technology has only begun to disrupt the structure of healthcare as a field and marketplace. We have not used the term 'disruptive innovation' to describe our advocacy of technology experimentation among clinicians, but it does fit. By definition, the term is used to describe innovations that improve a product or service in ways the market does not expect, first through designing for a different set of consumers. Clayton Christensen, the noted management expert, adds to this; "a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up in the marketplace, eventually displacing established competitors". [11] Putting patients at the center of the design process in terms of creating mental health care solutions is a radical idea. Let's explore and discover what can happen.

Finally, we are aware that our subject can be controversial. At a time when electronic gadgetry and the digital entertainment miasma appear to have a stranglehold on children and young adults, it may seem antithetical to suggest more technology is the answer to improved mental health service and delivery. What we have attempted to offer in this text is a more nuanced discussion of what it means to integrate new technology into clinical settings. Many clinicians *are* ready to launch a robust design culture as an extension of theory, skills, and treatments. We hope our book serves as a guide to those who want to make the journey. Metaphorically speaking, we acknowledge that a faction of our readers

will consider this a demand to 'walk the plank' to ruin. We see this challenge not as a threatening cliff, but a hill to walk over.

Endnotes

[1] Le Masson, P., Hatchuel, A., & Weil, B. (2011). The Interplay between Creativity Issues and Design Theories: A New Perspective for Design Management. *Creativity and Innovation Management,* Vol 20, no. 4, 217-238.
[2] Le Masson, P., Weil, B. & Hatchuel, A. (2010). Strategic Management of Innovation and Design. New York, NY; Cambridge University Press.
[3] Lave, J. & Wenger, E. (1991). Situated Learning: Legitimate peripheral participation. New York, NY: Cambridge University Press.
[4] LOGO resources and explanation; http://el.media.mit.edu/logo-foundation/logo/ accessed 02/02/2014
[5] Clough, B. and Casey, L. (2011). Technological adjuncts to enhance current psychotherapy practices: A review . Clinical Psychology Review, 21, 279-292.
[6] HITECH Act was originally passed in conjunction with the American Recovery & Reinvestment Act of 2009 and amended in 2011.
[7] American Academy of Child and Adolescent Psychiatry (2002). Practice parameter for the prevention and management of aggressive behavior in child and adolescent psychiatric institutions, with special reference to seclusion and restraints [Supplement]. Jrl of the American Academy of Child and Adolescent Psychiatry, 41, 4S-25S.
[8] Le Masson, P., Weil, B. & Hatchuel, A. (2010). Strategic Management of Innovation and Design. New York, NY; Cambridge University Press, p. 27.
[9] Recent news for venture capital investment: www.cbinsights.com/blog/venture-capital-2013-q1, accessed January 2014, www.mddionline.com/article/strategic-investors-or-corporate-venture-capitalists-are-very-active-healthcare-field, accessed January 2014, www.informationweek.com/healthcare/leadership/digital-health-startups-charm-vcs/d/d-id/1113328 , accessed January 2014.
[10] To view examples of CCNMTL coursework see: ccnmtl.columiba.edu/portfolio/exhibit_view.html
[11] Christensen, C. (2009). The innovators prescription: A disruptive solution for healthcare. New York, NY; McGraw-Hill.