Chapter 18
Commentary by Ray Brown on Real World Applications

An Essay on the Use of Sports Training (Tennis) to Prove Experimentally a Theory of Brain Dynamics

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Abstract In this work, we examine the basic problem of connecting a theory of the brain to the activities of humans engaged in the common pursuits of everyday life. This examination is explored through an implementation of a current dynamical theory, the KIII theory, which originates with Freeman (Neurodynamics: an exploration in mesoscopic brain dynamics, 2000, [4]) and is advanced mathematically by Kozma. Our venue is a sports training program which is chosen for its accessibility to all researchers. In order to carry out this examination we must use a mathematical framework that serves the purpose of capturing the dynamics of the Freeman-Kozma model (Freeman, Neurodynamics: an exploration in mesoscopic brain dynamics, 2000, [4], Ilin and Kozma, Phys Lett A 360:66–83, 2006, [7]) and which can also be applied to the activities of a human enterprise.

18.1 Introduction

> *And men ought to know that from nothing else but thence [from the brain] come joys, delights, laughter and sports, and sorrows, griefs, despondency, and lamentations. And by this, in an especial manner, we acquire wisdom and knowledge, and see and hear, and know what are foul and what are fair, what are bad and what are good, what are sweet, and what unsavory... And by the same organ we become mad and delirious, and fears and terrors assail us... in these ways I am of the opinion that the brain exercises the greatest power in the man.*—Hippocrates [6]

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What is at issue today in the quote of Hippocrates is this: If we succeed in constructing a dynamical model of the brain, how do we connect these dynamics to the behavior and actions of humans engaged in normal, everyday activities as Hippocrates claims? That is the central focus of this article.

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The sum total of our knowledge of the human brain arises from (1) experiments on animals; (2) medical cases of humans with some form of brain trauma; (3) statistical correlations from studies of psychology and sociology. However, direct quantifiable examination and study of normal humans engaged in normal activities is what would best confirm a theory. Specifically, direct quantifiable cause and effect data, rather than statistical correlations, are what is needed for sufficient proof of a neurodynamical theory.

18.2 Implementation of the KIII Model

To "prove" a neurodynamical theory it would be sufficient, in addition to accounting for laboratory experimental results, to answer the three key questions in Table 18.1.

Any program to prove a neurodynamical theory must be able to use normal human subjects performing normal human activities. To establish such a program three conditions must be met: (1) Find a simplified venue within which the key issues that bar our ability to answer these questions can be examined; (2) apply our knowledge of the dynamics of the human brain theory to this venue to construct a minimal system to test and prove hypotheses that will provide the foundation on which further developments can be based; (3) establish specifications for the design of systems which are broad enough to encompass a wide range of human enterprises.

In this paper I will select a venue for testing the KIII Theory and construct, using that venue, a minimal system that will address the three conditions cited above.

18.3 Selection of Mesoscopic Components

We begin by tabulating the minimal factors that must be instantiated in the sports training program based on an understanding of the KIII Theory and its implications:

While most of the factors in Table 18.2 are self explanatory, the factors of Fear/stress and ARTT require some explanation. A wave-pulse mesoscopic theory allows for rapid response to surprise, fear, stress and circumstances that challenge the limits of human performance. To test the KIII Theory it was essential to challenge the limits of human performance and endurance, particularly in responding to fast-paced events. To do this we introduced many stress related activities that contributed directly to student development.

Table 18.1 Key questions for proving a neurodynamical theory

1.	How is intentionality communicated to the relevant action regions of the brain?
2.	How do humans learn?
3.	How does the human rapidly adapt to change?

Table 18.2 The minimum number of factors that must appear in a training program to instantiate KIII Theory (ARTT)

Factor	Relevance
Sports specific mesoscopic components	Key to the KIII theory
Component purpose	Intentionality driven
Experimentation	KIII implies individual initiative
Numerous samples	KIII implies successive approximations
ARTT	KIII implies rapid responsiveness to extremes
Stress/Fear	KIII implies rapid adaptation to change
Complex environment	KIII is chaos driven
Hands off approach	KIII implies self organization

After some analysis it was decided that the athletic analog of a mesoscopic component from [4, 7] must be the simplest possible motor action component that would have a purpose. Purpose was included to assure intentionality was present. This was necessary for validation of the theory as well as the fact that this was well supported by the research of Langer [9] at Harvard. We know from the research of Langer that motivation or intentionality would be an essential component for learning as well as for neurodynamics. This was consistent with the KIV theory, and extension of the KIII Theory to include intentionality. The nature of tennis itself provided the answers we needed, see Table 18.3.

Each simple component was selected to be versatile, i.e., useful in serving more than one purpose.

In addition to the technical factors of the sport that required the derivation of mesoscopic components, we also had to consider two other factors: Physical conditioning and mental toughness. Without these additional components, no valid test of learning could be formulated since both conditioning and mental toughness both can "trump" technical skill. This meant that no matter how well mesoscopic components were acquired by the student, their ability to use these skills in the sport depended on their conditioning and mental toughness. In fact, skill could be completely lost due to

Table 18.3 Learning components in tennis

Mesoscopic component	Component action
Primary component	Contact between the racquet and the ball
Secondary component 1	Extension through ball path
Secondary component 2	Rotation of racquet head into ball path alignment
Secondary component 3	Acceleration of racquet into ball path
Secondary component 4	Initiate racquet forward advance
Secondary component 5	Retract racquet into starting position

the extreme stress of formal match competition [2]. As a result of these known facts, we had to develop a program that supported skill development with physical conditioning and mental toughness training. This consideration required that we derive our program from the principles of eye-to-eye combat. There are three that apply to all combat from MMA to Tennis to war and they are derived from the single most important principle of combat: to break the enemies/opponent's will to continue, Table 18.4.

Table 18.4 Principles in breaking the opponent's will

1	Intimidate the opponent
2	Make the opponent feel physical pain
3	Inspire fear in the opponent with your assault

Fig. 18.1 Mesoscopic component analysis and conditioning program

To develop mental toughness we introduced the MMA training protocols of current bantam weight champion Ronda Rousey to further amplify the primitive demand on the mind and body. This included using MMA equipment such as body protectors to be able to include striking in the protocols. However, no head striking was allowed due to its risk of injury, see Fig. 18.1b. To assure that physical fitness was never a factor in skill performance, we developed an extensive physical fitness program, Fig. 18.1c. Each component of the physical fitness program had to be tied to mesoscopic component development. This assured that the exercise was relevant and driven by intentionality.

18.4 Example Results

Our research and analysis concluded that the instruction protocol would have to diverge drastically from legacy tennis training approaches. Most importantly, as our analysis from paleoanthropology shows, the role of language or explicit instruction would require significant attenuation. As a consequence, micromanagement of the student would have to be eliminated and replaced with a minimalist approach whereby the instructor was "nearly" a bystander. This element of the protocol also supported the non interference requirement necessary to assure minimal corruption of the data but also was consistent with the KIII Theory. Consistent with the mesoscopic wave-pulse approach would be the inference that once a component was developed, it would be used in a variety of contexts without the need for explicit direction [6]. This drove the protocol to depend on the individual's initiative and creativity to "fill-in-the-blanks" with minimal assistance from the instructor. Therefore experimentation and exploration by the student was a necessary ingredient of the protocol. Further, the derived training protocol must make maximum use of mimetic learning which can proceed at a remarkable pace [8] sometimes just a few minutes is all that is required. This is fully consistent with the mesoscopic wave-pulse theory and is also well-supported by the theory. Chaotic dynamics would be necessary as well. Chaos was included in several forms: constantly changing schedules; a random order of exercises and drills; surprise changes from projected schedules etc. The demand to adapt quickly is a consistent and necessary theme that must run through all training exercises and drills. The drills and exercises had to challenge the brain to develop and adapt due to the inherent difficulty of the program.

Within this complex environment, students from all walks of life were trained to play tennis and to execute even the most difficult and complex actions of the sport. Clearly, the demand to rapidly adapt to change in the face of fear and complexity is best explained by the mesoscopic wave-pulse theory. Another implication of this theory is that a part of the brain that originally starts out having a specific function could be reconfigured in a short time span to perform a different function based on the level of desire of the subject. A common example is that of the individual who, after losing the use of their arms, learn to use their feet for the original purpose for which the hands were used. An additional implication is that learning a sport must

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proceed from intense, nonverbal environmental activity [1]; further, the process of trial-and-error must be permitted [9]. One significance of including trial-and-error is that it allows for the brain to “self organize” over very short time spans. Short-term self organization is consistent with the KIII wave theory but not with the static neuronal theory.

While our approach is to train normal subjects using the KIII protocol, having functionally normal subjects with some accidental or embedded abnormality would be most useful. Using this approach, a simple test of the KIII hypothesis could be conducted if a subject entered our program with a known physical limitation. This had to occur by chance since proselytizing and advertising were prohibited. As chance would have it over a 16 year period, players did arrive on our door step who had lost some range of motor action. We will only mentioned three here.

Case 1 The first medical case is of a subject who entered our program with an inoperable tumor on his brain stem. See Fig. 18.2b which includes the MRI of Dan T.

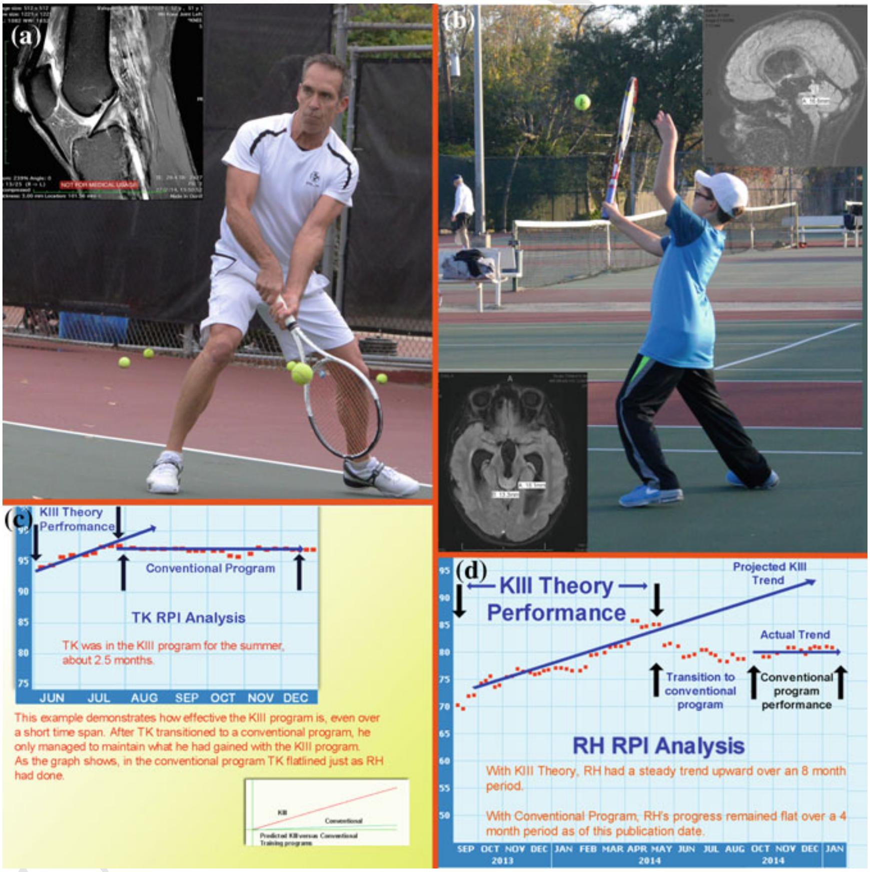

Fig. 18.2 Experimental results

dated 2011; and, the figure also shows Dan T. is performing effectively in competition. His prognosis was not fatal, but that his ability to engage in complex athletics would likely never be possible. At one point, the mother of Dan T. was told not to remove Dan from hospital care because he would die. She ignored the doctor's advice. By chance Dan T's family was a member of the Plaza Oaks Club in Houston, TX out of which this tennis academy operated. She brought him, and his younger brother to Jana van der Walt, our head pro to begin lessons. Within two years Dan T was defying all the odds and learning to play tennis well enough to compete in formal sanctioned tournaments. In his second match, played in December of 2014, Dan T took his match to a third set tie-breaker against a far superior normal student.

Dan T's starting point in our program requires mentioning. When Jana began feeding Dan balls that were high, he would duck; on some occasions the ball would hit Dan as he was unable to make decisions about how to adjust to the ball path. The significance of this is that in Fig. 18.2b, Dan is hitting a ball out of the air in a formally sanctioned USTA tournament. This photo demonstrated that not only had Dan formed the mesoscopic components of movement to adjust to, and track the ball in an extraordinarily short time span, he did it under the pressure of competition.

Serendipitously, two important points emerged from the fact that Dan T was trained independently by Ms. Walt without any advice beyond following the KIII training protocol: (1) the method itself was demonstrated to be transferable; and, (2) that implementing the KIII Theory in a sports venue may be independently verifiable.

Case 2 A second example is that of Jean V. See Fig. 18.2a. Jean V destroyed his knee in motor cross training. The exact diagnosis from the MRI of the left knee joint was: *Acute full thickness versus near complete mid substance tear of the posterior cruciate ligament. Anterior cruciate ligament is intact. High grade sprain of the of the proximal superficial medial collateral ligament. Moderate tear of the medial collateral ligament. There may be a complete tear at the femoral origin. Oblique tear within the middle and peripheral thirds of the posterior horn of the medial meniscus.* The rest of the knee was found intact.

Jean V's injury was a result of a fall while involved in motor cross training. Surgery was recommended, however, Jean V elected to use our program as a rehabilitation venue on the premise that his brain would, with extreme intentionality and determination, shortly reroute his muscle groups to allow him to return to playing competitive tennis. Full dynamic recovery occurred within less than three months. In addition to Fig. 18.2a, Jean can be seen grappling in the MMA figure, Fig. 18.1b, bottom right.

The foregoing examples are of students who had some limitation that was readily overcome by the KIII teaching methodology. The following examples are two students who have no limitations and were candidates for professional tennis. However, the student's parents thought that they could do even better and moved the student to another program. This provided us with an excellent opportunity to make a direct comparison of KIII theory development with conventional methods. A key to understanding the figures is the RPI, or Relative Performance Index. This is a number that is calculated each week by IMG for all amateur sports. It measures the candidates performance relative to their competitors. This is the only relevant decision making factor that is a pure number that is important to scholarship decisions or other coaching decisions.

In Fig. 18.2d, we show the RPI of the KIII theory beginning around September 2013–April 2014. At this time the parents moved the student to a conventional program after a short transition period. The conventional program started in September 2014 and is still in progress at the time of this publication. In addition to this case, there have been several other cases where, for various reasons, the student had to transition to a conventional program with the same relative RPI results.

Of particular significance is that during the student's KIII training period we see steady improvement well beyond the expected. On the other hand, when the student returned to a conventional program, the RPI flat-lined. In Fig. 18.2c, we show the RPI of for a short time duration student in the KIII theory beginning around June 2014 to the beginning of August 2014. At this time the parents, as with RH, moved the student to a conventional program. The conventional program started in August 2014 without a transition period and is still in progress at the time of this publication. After examination of several more cases, we are predicting that the KIII program will out perform conventional training by a significant margin. This prediction is illustrated in the bottom right of Fig. 18.2c where we predict that the conventional program will reflect slow but steady progress whereas the KIII program will produce very rapid progress. If these results can be replicated in rehabilitation programs, this would mean that a rehabilitation program derived from the KIII theory could result is very significant improvements in every form of rehabilitation.

18.5 Summary

In this paper we have demonstrated how to instantiate the KIII Theory in a tennis training venue which is a very simple model of a human system involving competition, stress, rapid development and complex decision making. The objective results on the USTA tournament Websites demonstrate that students who have come through this system compete very effectively against students that have been trained in conventional protocols and that even students with limitations have developed far faster than is possible using other systems. This would suggest that the KIII Mesoscopic Wave-pulse Theory provides a very effective training protocol when translated into practice.

Acknowledgments While many students passed through our program over the years, we would like to acknowledge those who can be clearly identified with our program. To do this we confine our acknowledgments to those who were in the program at least two years; or, based their development directly on using the KIII Theory protocols; and, who are present in our program as of December 30, 2014.

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Chapter 18

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