

Brainwave Connections

Dedicated to communication and education in the emerging fields of neurofeedback, mental fitness, neuromeditation, and brain modification

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ON PERSONAL CONNECTIVITY

Sometimes, we can learn something simply by thinking about the obvious. Take, for example, the obvious truth that everyone has exactly two parents. Not at least two, not at most two, but exactly two. Necessarily.

Let us take this simple observation to some of its logical conclusions. Along with the fact that it takes an average of 20-30 years for each generation. Based on this beginning, we make several deductions. The obvious one is that everyone must have 2 parents. If either one of them had not existed, you would not have been born. You owe your existence entirely, and totally, to these two people, whose DNA you share. A next conclusion is that every person must have at least 4 grandparents, ancestors at the "2-generation" mark, which is approximately 50 years ago. And each of these 4 people must have existed, for you to be here today. Similarly, everyone must have 8 ancestors at the "3-generation" mark, approximately 75 years ago. And clearly, if any of these great-grandparents had not existed, you would not be reading this today.

Taking this to its logical extensions, let us consider a time 200 years ago. Since this is approximately at the "7-generation mark", you will necessarily have 128 ancestors around this time. If any one of them had not existed, you would not be here today. You owe your very life to these 128 special people, each one of whom contributed materially and necessarily, to your existence, and whose DNA you share.

Who were these 128 people in the year 1806? What did they think? What did they feel? Did any of them know each other? What were their hopes and dreams? Their

achievements and disappointments? Did they realize that at some point in the unforeseeable future, a very significant part of the human experience would depend upon their exploits?

Take this reasoning to a point of time 500 years ago. At this time, 16 generations ago, you would have something like 100,000 ancestors. This is a very large number. It would exceed the size of any typical town, and a group this size would constitute a significant force. And every one of these people was necessary to your future existence.

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ANI Z DLL



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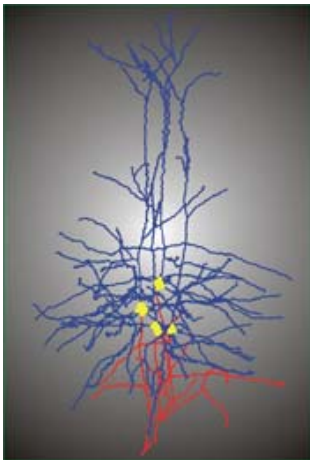
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**HOMAGE TO THE ANCESTORS—
HISTORICAL MUSEUM OF
SOUTHERN FLORIDA**

CONNECTIVITY, INHIBITION, AND PATH-SPECIFIC

The dictum that life's aim is an act not a thought must be modified to admit that, often, to refrain from an act is no less an act than to commit one, because inhibition is coequally with excitation a nervous activity.

-Sir Charles Sherrington



Computer reconstruction of four pyramidal neurons from somatosensory cortex layer 5.

(Image by Dr. Qian-Qan Sun, University of Wyoming)

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The brain is a hyperconnected system. It contains on the order of 10 billion neurons, each of which can have hundreds or thousands of connections to other neurons. The brain depends on dynamically managing trillions of connections, to regulate the interactions between all of its parts (Calvin 1995, Sejnowski 2004)

How are all of these connections managed toward useful ends? The key lies in the ability of the network to selectively enable or disable connections, based upon a simple model of excitation and inhibition.

Connectivity refers to the mechanism by which parts of a system work together, via communication and control. Connectivity results when information is shared between parts, and used in a coherent manner to produce sensation, perception, decision-making, and behavior.

One of the most important functions in the brain is that of inhibition. This is true on the microscopic level, and also on the macroscopic level. Early sensory experiences have profound effects on the fine structural and functional organization of the brain. . (e.g. Jiao 2006). A great deal of this adaptation takes the form of creating and shaping connections between neuronal assemblies, mediated by the dynamic balance of excitatory and inhibitory connections in the network.

In the words of Sir Charles Sherrington (1933), *The dic-*

tum that life's aim is an act not a thought must be modified to admit that, often, to refrain from an act is no less an act than to commit one, because inhibition is coequally with excitation a nervous activity.

When we examine the synaptic inputs a typical pyramidal cells in the cortex or even in the thalamus, we see that in excess of 90% of the inputs to a particular cell may be inhibitory. Only a small fraction are typically excitatory, inasmuch as most neurons are inherently excitable by virtue of their membrane properties, and need to be "sedated," more than they need to be even more excited.

A great deal of inhibition is in the form of collateral inhibition. This takes place when collateral fibers in a pathway inhibit each other whenever information is being sent. As a result of this inhibition, neuronal bundles and tracts are able to transmit information with sharpness, fidelity, and high resolution.

As an example of the power of this fidelity, consider that the auditory nerve can respond with action potentials to a deflection in the basilar membrane of no more than 1 Angstrom, which is the diameter of a hydrogen atom. This reveals unimaginable acuity in the physiological and neuronal mechanisms at work. Similarly, the eye is capable of seeing a candle light at 12 miles, which corresponds to a stimulus rate of one photon per second. If neuronal signals were allowed

to mix and scramble, such acuity and precision would not be possible. Without inhibition at a cellular level, brain activity would degenerate into pure chaos including seizure activity, devoid of purposeful control or meaning.

At the larger systems level, inhibition is an important component to brain function. Jeffrey Carmen has observed that the reaction of a chicken to having its head removed is to flap its wings, run about, and attempt to squawk, before finally expiring. The function of the chicken's brain is more to inhibit automatic mechanisms than to instigate specific behaviors. In the same way, Carmen refers to the frontal lobes of the human brain as the "chicken's brain" of the entire brain. That is, the frontal lobes spend the majority of their activity inhibiting activities, including behaviors, that the rest of the brain is all too ready to undertake. This explains why dysfunction of the frontal lobes often results in disorders characterized by a lack of inhibition of thoughts or behaviors that are detrimental to the individual.

When EEG training is performed at the level of brain connectivity and communication, it becomes possible to address directly the relative excitation and inhibition, but particularly the inhibition, of neuronal pathways and joint functioning.

Thus, whereas conventional EEG amplitude training ad-

RELAXATION TRAINING

dresses synchrony at a local level, connectivity training addresses synchrony at a global level, and in a manner specifically targeted at neuronal assemblies and their interaction.

When we examine the thalamocortical relay circuits and their role in generating EEG brain rhythms, it is evident that measurable brain signals are produced when existing circuits are disinhibited (relaxed), allowing the cortical cells to participate in a volley of activity. There are inhibitory connections at both the thalamic and at the cortical levels, that hold these rhythmic circuits at bay, so that the brain can process information, perform cortico-cortical interactions, and generally be involved with higher-frequency, beta-like activity.

In other words, relaxation at the level of individual neurons and neuronal connections, is one primary mechanism that is addressed when the brain is challenged to modify its EEG activity through training.

Whereas amplitude training addresses neuronal synchrony at the local level, connectivity training addresses neuronal synchrony at a nonlocal level. And one mechanism that the brain uses to alter nonlocal synchrony is to dynamically reconfigure connections, and this is accomplished largely by modulating inhibitory influences on participating cortical pathways.

This can all be related back to the core issues of stress, re-

laxation, flexibility, and appropriateness of brain state. A considerable degree of ills can be ascribed to dysregulation in the central nervous system, predominantly the form of disturbances of normal rhythms and patterns of excitation (concentration) and relaxation. In the same way that a chronic stone in a shoe can cause one to throw a hip out of joint, chronic misadjustments in neuronal circuits can lead to long-term patterns of dysfunction with myriads of clinical manifestations.

Healthy brain function depends upon the continual operation and maintenance of dozens of major pathways that connect functional areas together to accomplish complex tasks. Researchers at Brown University, for example, have shown that Alzheimer's patients exhibit an inability to bind information from dorsal and ventral visual streams, as revealed in a global motion coherence task. This neocortical disconnectivity is manifest in deficits in sensory integration and attention.

Through EEG connectivity training, we address these types of issues in a form that appeals to relaxation, normalization, and restoration of normal levels of communication and control. If, for example, we use 4 brain sites, for example F3, F4, P3, and P4, we are able to train amplitudes at 4 locations, but also to train connections along all 6 paths. This provides a level of information that is not accessible with methods based solely on am-

plitudes, or on simple coherence or synchrony targets.

The monitoring and feedback of complex information relating to brain connectivity is made tractable by methods such as live Z-score feedback. This makes it possible to address the complex interplay of brain activity with an eye toward appropriateness of brain connectivity, in addition to working with the basic elements of local excitation and relaxation.

Through a cohesive approach to path-specific relaxation training, we open the door to teaching the brain complex interactions that are much more akin to real-world tasks. To use a physical analogy, we can move from simply lifting weights to doing the mental equivalents of walking, riding a bicycle, or even doing yoga. This will allow us to work more directly with neural coherence and assess its importance whenever learning, memory, attention, language, or other complex mechanisms are dysregulated.

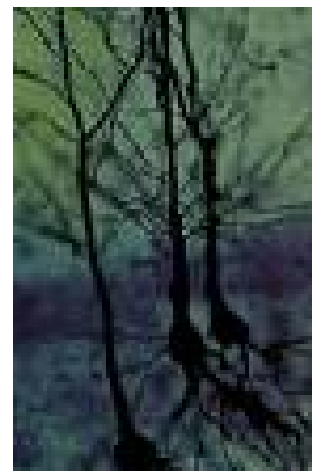
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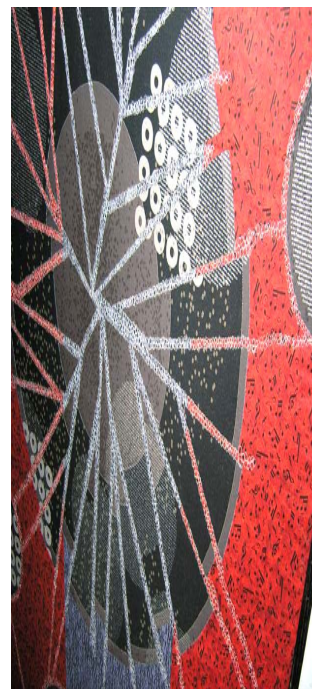
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Three Pyramidal Neurons

(Image by Stanford University Neuropharmacology Laboratory)



Connections

By Ann Pugh

Brainwave Connections

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Product Review

The ANI Z DLL

by Dr. Robert Thatcher & Applied Neurosciences

In this column, we usually review a book or journal. Such resources provide important knowledge and understanding, useful in guiding clinical as well as research plans and procedures. In this issue, we look at a software product that embodies its own knowledge base and automation, thus providing expertise on the spot, and in a functional form. Dr. Robert Thatcher (Applied Neurosciences, Inc. and the University of Florida) is a clinical researcher who has worked in EEG, brain function, coherence and consciousness, and digital signal processing. He is the author of the NeuroGuide software system that performs offline (post-processed) quantitative and normative analysis of EEG.

The ANI DLL takes this work an important step further, in providing real-time feedback in which the targets are "Z scores" instead of conventional EEG metrics. Z Scores are computed and targetable for training protocols, based on the software capabilities and flexibility built into the host EEG hardware and software. BrainMaster is the first to provide this capability in an EEG training system. Z Scores are computed and targetable for absolute and relative power, power ratios, asymmetry, coherence, and phase for 1, 2, or 4 channels. Targets can be combined to provide comprehensive training using auditory or visual feedback, animations, games, DVD's, etc. In the 4-channel embodiment, 4 brain locations and 6 interconnecting pathways can be trained simultaneously, providing comprehensive whole-brain training. In addition to protocols for training toward normal EEG parameters, targets can be biased for peak-performance applications, deep states training, or other applications.

Educational and training opportunities are available through Stress Therapy Solutions, and are also offered at meetings such as AAPB, ISNR, Futurehealth, and the SAN.

ON PERSONAL CONNECTIONS—FROM PAGE 1

1000 years ago, 33 generations in the past, you would lay claim to no fewer than a billion ancestors. But this number exceeds the population of the earth at that time. Clearly, you cannot have a billion unique ancestors in the year 1000. There weren't enough people to go around.

This means that, inevitably, ancestors in one part of your family tree also occupy spots on other parts of your tree. That is, if you go back far enough, your mother's mother's father's father's mother's mother's father's ... father could be the same person as your mother's father's father's mother's mother's father's mother's ... father, and this is very, very common. There is a lot of blending and sharing going on, and to a staggering degree.

At the 2000 years-ago mark, the number of putative ancestors is an astonishing 1,152,921,504,606,846,976. This is about a trillion times larger than the population of the earth at that time. The way to resolve this enormous discrepancy is to accept the fact that we are all cousins, and have been, ever since a few thousand hominids set out about 75,000 years ago on the journey we call being human. The very idea that we are separate beings is an illusion.

This compels us to recognize that we cannot likely trace our connectivity backward in any simple sense of localized, limited heritage. Rather, we necessarily share identity and genetic information with a vast and distributed population that is both widespread and well mixed. The numbers compel it.

In other words, the earth is already an island sufficiently small that, over the last millennia, we are already interconnected to an extraordinary degree.

Which bears on the theme of connectivity and connectedness. The earth now has on the order of 10 billion inhabitants, which is similar to the number of neurons in a human brain. Is it there that the resemblance ends, or might there be something more ahead?

