**The Gift of Neuroplasticity**

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**With the statute of limitations having long expired, I can now describe my first experiences in learning about the human brain. When I was a child, I didn’t have the opportunity to spend much time with my father as he maintained a very busy practice in neurosurgery in South Florida. Clearly, he too recognized this shortcoming in our relationship so one day he came up with a solution; he invited me to come to the operating room to watch him remove a tumor from the base of someone’s brain. What a way to spend a Saturday afternoon, especially considering the fact that I was thirteen years old at the time. I soon made these visits to the operating room a regular part of my weekend and retrospectively I believe my dad made the effort to schedule surgery on Saturdays so I could join him. The only problem was that despite standing on a step stool, I found it difficult to really see what was going on. Resourceful as my dad was, he came up with what would be considered today as a fairly risky solution. He encouraged me to “scrub in.” That is, at the age of fourteen, I was actually assisting my father as he performed all kinds of brain procedures from removing tumors or blood clots to clipping aneurysms. Needless to say, I was careful not to share these experiences with my friends.**

**My job generally entailed holding a thin flat metal “brain retractor,” gently providing enough pressure on the brain to allow my dad to do his work. Often, these procedures would take many hours so to pass the time my father would explain the specific function of that part of the brain upon which we were operating. “This area,” he would say, “is called Broca’s area, named for Pierre-Paul Broca, a French fellow who back in 1861 determined that this area controlled speech.” He went on to describe the rest of the areas of the brain in the same detail, always weaving some bit of historical color into the description.**

**These early experiences provided me a rich and expansive understanding of the brain, at a very impressionable time in my life. The idea that specific parts of the brain were dedicated to specific functions was reinforced with the brain research I pursued in college and was one of the key themes in my early publications in the Journal of Neurosurgery. Medical school further stressed the notion that specific parts of the brain were “assigned” to particular functions, and certainly this mentality was pervasive throughout my years in neurology training. Indeed it was often said that neurologists learned functional brain anatomy, “stroke by stroke.” That is, when a patient was admitted with a stroke in a particular area of the brain, correlation with the physical disability would show what function the damaged brain area subserved.**

**This structure/ function relationship began to unravel, at least for me in the late 1980s when I began to note that some patients would regain considerable function of a particular area following a stroke even though there had been no observable change in their imaging studies. So while a patient’s MRI continued to show damage in, for example, the part of the brain controlling the left hand, not infrequently, the brain would “heal,” an observation not uncommon amongst neurologists, therapists, and the general population as well.**

**Michael, a 58 year old graphic designer from North Carolina came to see me in 1988. He reported that fourteen months prior to his visit he developed a fairly sudden onset of inability to speak. “I knew what I wanted to say, but I just couldn’t produce the words,” he recounted with perfect fluency. My first thought was that he had experienced a “TIA” or transient ischemic event, characterized by a brief decline in blood supply to a particular region of the brain. But as he continued, he revealed that his speech had been fairly compromised for at least six months following the attack. There was nothing “transient” about it. We reviewed an MRI scan of his brain done just two months prior to his visit at our clinic, and there, for all to see, was evidence of severe damage and loss of tissue in not only the speech area, but in the adjacent areas associated with facial movement and control of the right arm. Nonetheless, his examination revealed no deficit whatsoever. What had happened? Clearly, his brain hadn’t “healed” as the area of his initial stroke was still damaged as his MRI so clearly revealed.**

**Clearly his brain had adapted, that is, his brain began to use alternative pathways to regain function, an idea that was considered fanciful, even into the late 1980s.**

**The ability of the brain to change and reorganize itself and its function is called neuroplasticity, and it is a gift on par with neurogenesis, our ability to generate new brain cells throughout our lifetimes. Neuroplasticity provides us with a brain that can adapt not only to changes inflicted by damage, but more importantly, allows adaptation to any and all experiences and changes we may encounter, freeing us from merely responding reflexively as a consequence of genetically determined hardwiring. Harvard Medical School’s Dr. Alvaro Pascual-Leone recently stated that neuroplasticity “… is an intrinsic property of the human brain and represents evolution’s invention to enable the nervous system to escape the restrictions of its own genome and thus adapt to environmental pressures, physiological changes, and experiences.”**

**How does neuroplasticity come about? While the individual working unit of the brain is the single neuron, even simple tasks require the recruitment of vast numbers of interconnected neurons functioning as a unit or network devoted to accomplishing even the simplest activity. Dr. Joe Dispenza, in his book, Evolve Your Brain, eloquently described the neural network as, “…literally millions of neurons firing together in diverse compartments, modules, sections, and subregions throughout the entire brain. They team up to form communities of nerve cells that act in unison as a group, clustered together in relation to a particular concept, idea, memory, skill, or habit. Whole patterns of neurons throughout the brain become connected through the process of learning, to produce a unique level of mind.”**

**The neural network represents a specific unique pattern of connections of neurons that fire in a specified sequence that allows you to accomplish such tasks as snapping your fingers, or recalling the lyrics to Hey Jude. And neuroplasticity, the ability of the brain to adapt and change, is predicated on the modification of existing neural networks and the creation of new ones.**

**We have come a long way in the past twenty-five years in our understanding of the brain, from a generally accepted perception of the brain as being a hardwired, fixed and immutable organ to one that celebrates its dynamism.**

**What had occurred in Michael’s brain that allowed him to regain function was the creation of new neural networks; new connections opening up new pathways in his brain that, fortunately for him, allowed for dramatic return of function. But how do individual neurons actually connect? What motivates the connection and keeps them connected? The pioneering research in this area dates back to the work of Canadian psychologist, Dr. Donald Hebb who proposed a theory he felt would explain how neurons could develop a relationship with one another. In his landmark book, The Organization of Behavior, published in 1949, Dr. Hebb hypothesized, “When an axon of cell A is near enough to excite cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A’s efficiency, as one of the cells firing B is increased.” Or more simply paraphrased, “neurons that fire together, wire together,” commonly referred to as Hebb’s law. When neurons combined in a unit dedicated to a specific function, we now refer to as neural networks, Dr. Hebb applied the term, “cell-assemblies.” Clearly, Dr. Hebb was well ahead of his time in his understanding of brain physiology. And we now have a handle on the “growth process” or “metabolic change” about which he speculated. And while the precise biochemical changes that take place when neurons connect to form these networks is quite complex, there is general agreement among researchers that BDNF (brain-derived neurotrophic factor), BDNF, creates the fertile ground for this union to take place, helping transform a mere embrace of two neurons into an eternal dance.**

**Thus, enhancing BDNF represents a key modifiable factor in the process of neural network formation. As such, BDNF is now looked upon as playing a pivotal role in neuroplasticity. Modifiable behaviors which upregulate BDNF transcription include physical exercise, the omega-3 fatty acid DHA, and caloric restrictions.**

**Neurons develop a relationship that facilitates future coordinated activation as a response to being repeatedly stimulated. This is how networks are constructed. While it is quaint to consider the beauty of Tiger Woods’ golf swing as representing a pinnacle in the development of “muscle memory,” the real credit for his performance lies in the memory encoded in the neural networks in his brain that have been refined through years of practice.**

**But it takes more than simple repetition of a stimulation or activity to create the brain connections that lead to the formation of neural networks. Dr, Michael Merzenich, professor emeritus at the University of California, San Francisco, performed a series of experiments in the mid 1990s demonstrating the importance of attention in the formation of neural networks. In one experiment with monkeys, he applied a tapping stimulus to the fingers of two groups of monkeys. Occasionally, the rhythm of the tapping would change. In one group, responding to the change in the tapping would result in a reward; a sip of juice. In the other monkeys, a change in the tapping did would not provide any reward, even if the monkeys responded to the change. After six weeks, examination of the monkey’s brains revealed profound changes in the monkeys who, by virtue of being rewarded, paid close attention to the stimulus, waiting for the rhythm change. Specifically, changes were recorded in the specific area of their brains that was involved in processing stimulation to the fingers. No such changes were observed in the monkeys who weren’t paying attention to the stimulus, despite the fact that the stimulus, the tapping on their fingers, was exactly the same. Looking back on these results and considering the implications for humans, Dr. Merzenich remarked,”**

**Experience coupled with attention leads to physical changes in the structure and future functioning of the nervous system. This leaves us with a clear physiological fact…moment by moment we choose and sculpt how our ever-changing minds will work, we choose who we will be the next moment in a very real sense, and these choices are left embossed in physical form on our material selves…” In essence, creating neural networks, and indeed the process of neuroplasticity, requires focused attention. As Dispenza stated,” The key ingredient in making these neural connections…is focused attention. When we mentally attend to whatever we are learning, the brain can map the information on which we are focusing. On the other hand, when we don’t pay complete attention to what we are doing in the present moment, our brain activates a host of other synaptic networks that can distract it from its original attention. Without focused concentration brain connections are not made, and memory is not stored.”**

**And as Sharon Begley summarized in a recent article in the Wall Street Journal, “The discovery that neuroplasticity cannot occur without attention has important implications. If a skill becomes so routine you can do it on autopilot, practicing it will no longer change the brain. And if you take up mental exercises to keep your brain young, they will not be as effective if you become able to do them without paying much attention.”**

**So becoming mentally engaged with an activity is requisite for learning that activity. We can choose to strengthen those pathways that serve us in positive ways. And as we will see later on, this is the science that underlies our ability to choose to enhance our ability to connect with the divine energy field that permeates our existence. Moreover, the corollary of Dr. Hebb’s “neurons that fire together, wire together” thesis provides the understanding that neurons that don’t fire together may ultimately not remain wired together. So activities need to be maintained if their neural networks are to remain functional. This may sound familiar and distressing, but the “glass full” aspect of this concept is that it allows for the disappearance of dysfunctional or detrimental networks when attention is directed away from them.**

**But the story gets more exciting. Research now demonstrates that just the mental aspect of an activity is enough to create the neural connections associated with learning it. In 1995, Dr. Pascuel-Leone conducted experiments in which he demonstrated changes in the brains of individuals only mentally practicing a piano exercise. These brain changes that were virtually identical to those seen in subjects who actually physically practiced the instrument. These subjects demonstrated that the mere act of thinking about an activity imparted physical changes in the brain.**

**And it is this profound discovery that has become a focal point of unified interest in discourse amongst philosophers, scientists, and theologians alike. As Schwartz and Begley propose in their groundbreaking book, The Mind and the Brain, “ … the time has come for science to confront the serious implications of the fact that directed, willed mental activity can clearly and systematically alter brain function; that the exertion of willful effort generates physical force that has the power to change how the brain works and even its physical structure. The result is directed neuroplasticity.”**

**Yes, it is breathtaking to consider that we have the will to physically and functionally change our brains. And while the fact that research demonstrates that simply contemplating a physical activity can make these changes, the brass ring involves taking the final step. That is, exploring the effect of mental attention not associated with any physical activity or dedicated to episodic or declarative memory; mental attention directed in such a way as to facilitate the experience of what has been variously termed universal intelligence, Zero Point Field, Source, God, Divine Matrix.**

**Dr. Andrew Newberg, director of the Center for Spirituality and the Mind at the University of Pennsylvania also maintains what may at first blush seem to be another seemingly incongruous appointment; associate professor of radiology. These titles are reconciled however, as he has devoted his career to examining how the practice of meditation changes both the structure and function of the brain as revealed by sophisticated imaging techniques. In his latest book, How God Changes Your Brain, Dr. Newberg describes his breakthrough findings not only demonstrating the specific areas of the brain that are modified by meditative practices, but in addition, eloquently details the function of these areas in terms of the positive effects behaviorally and emotionally imparted on the meditation practitioner.**

**Newberg’s work has shown that the practice of meditation enhances blood flow as well as function in an area of the brain called the anterior cingulate, an evolutionary newcomer that mediates our experience of empathy, social awareness, intuition, compassion, and our ability to regulate emotion. This structure sits in the front of the brain and wraps around the front part of the corpus callosum, the thick network of neurons that bridges the two hemispheres together. In addition to these functions, the anterior cingulate mediates communication between the amygdala, one of our most primitive brain structures, and the prefrontal cortex, a crowning evolutionary achievement and a purely human brain attribute.**

**The amygdala is a small almond-shaped structure situated in the front of each temporal lobe (there are thus two). It governs our so-called “fight or flight” automatic and instantaneous responses to real or imagined threat. Basically, it is the “fear center” of the brain, important for our survival as it allows us to respond to dangerous situations reflexively and unconsciously as opposed to actions based upon the deliberate and calculated input from the far more sophisticated prefrontal cortex. Unlike the amygdala, the prefrontal cortex allows for measured, careful responses to situations, giving consideration to various outcome possibilities and allowing for the evaluation of the implications of various choices.**

**The anterior cingulate thus stands at the crossroad. Its functionality or lack thereof helps determine whether our day to day behavior is reflexive and fear motivated, or is a manifestation of our uniquely human attribute of recognizing the array of implications and consequences of our choices. With enhancement of the anterior cingulate’s function comes better connection to behavior based on the latter along with enhanced empathy, social awareness, intuition, compassion, and our ability to regulate emotion. And Dr. Newberg has quite graphically shown, using the latest technology in functional brain mapping, that spiritual practices like meditation strengthen the anterior cingulate while at the same time calming the activity of the primitive amygdala.**

**On the other hand, anger has exactly the opposite effect. Anger basically shuts down the communication to the prefrontal cortex as mediated through the anterior cingulate. Emotion and fear take over in determining behavior. As Newberg puts it, “ Anger interrupts the functioning of your frontal lobes. Not only do you lose the ability to be rational, you lose the awareness that you’re acting in an irrational way. When your frontal lobes shut down, it’s impossible to listen to the other person, let alone feel empathy or compassion… When you intensely and consistently focus on your spiritual values and goals, you increase the blood flow to your frontal lobes and anterior cingulate, which cause the activity in emotional centers of the brain to decrease.”**

**Bridging our primitive emotional response areas with our highly evolved contemplative prefrontal cortex coupled with extensive connections with other brain areas allows the anterior cingulate to mediate how we perceive ourselves and our actions in relation to others and to the rest of the world, and beyond. And because the function of this circuit is enhanced by meditation, Dr. Newberg believes, “… there is a coevolution of spirituality and consciousness, engaging circuits that allow us to envision a benevolent, interconnecting relationship between the universe, God, and ourselves.”**

**So the gift of neuroplasticity, a process enhanced by repetition, attention, caloric restriction, and adequate dietary DHA, is the physical and functional link between meditation and connection with divine energy.**