"Music - the Brain's Software"

Joel M. Oster, MD, Neurologist
Jerzy Sapieyevski, Composer/Pianist

Music has a time-honored association with science. The ancients regarded music as a science of measurement to be classified with geometry, astronomy, and mathematics. Musical order was considered a reflection of the harmony of the universe and a bridge to the harmony of the mind and spirit.

Study after study shows the incredible impact that music making has on human development, mental, and physical well-being. With greater frequency, medical professionals are utilizing music as a tool for enhancing the capacity for healing.

An explosion of advances in neuroscience has revolutionized the study of the brain in recent years. The fields of neurology, neurosurgery, basic science and radiology using techniques such as MRI, functional MRI, metabolic imaging, cortical stimulation and neurosurgical techniques and removal of tumors and targeted lesioning and treatments and other specialized techniques such as opto-genetics and others to name a few- have given us a massive compendium of data and knowledge in the last several decades.

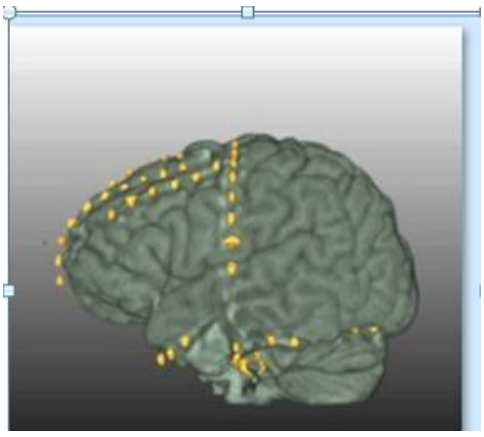

Figure: Image of a 3D Sagittal surface volume rendering 1.5 T MRI technique of a patient with MRI safe implanted electrodes on the brain for the study and localization of the onsets of epileptic seizures.

Scientists and physicians are now for the first time amazingly able to identify and map out the important or key brain regions and their projections or synapses within the brain itself to define the relevant anatomy and physiology of what actually comprises certain disease states such as what happens when we sleep or when we have the onset of sleep pathologically such as in narcolepsy and cataplexy (which localizes to the top of the brainstem and deep frontal lobe of the brain near the pituitary and optic chiasm) or what happens during even a simple thought or map internally what happens with a basic perception of any of our five senses.

Not only can MRI show the folds of the brain (gyri) and various anatomical regions but frankly beautiful images and pictures involving molecular biology and imaging techniques can illustrate the internal manifestation of what happens in the brain just before a movement occurs, just before or as a seizure starts or propagates, or where in the brain we feel certain emotional states.

Former Nobel laureates Hubel and Wiesel helped us understand what types of visual stimuli make certain cells in the hind part of the brain or occipital regions hyperactive and fire in various ways and organize into neural networks allowing us to see. We can identify exactly where in the brain epileptic seizures may begin and we can often remove or modify those regions to produce medical miracles and cures.

Scientists and physicians are working on using genetics and targeting certain neurons in order to treat diseases with metabolic dysfunctions in the future. We are also just beginning to scratch the surface on effectively modulating the brain to cause rehabilitation after a stroke, and to treat depression and pain using magnetic stimulation. Implanted electrodes may sense the beginnings of seizures and fire back a volley of neutralizing electrical current to abort them. Scientists are using chips to link and couple thoughts to moving computers and artificial limbs - just to name a few things currently being studied in the current modern state of the art academic research programs.

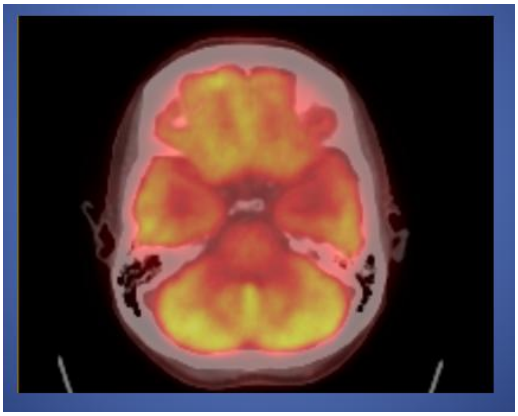

Figure: Fused imaging of 18 Flurodeoxyglucose PET scan with CT imaging showing relative left temporal dysfunction in a patient who had weaker verbal memory and skills as opposed to Visuospatial memory, patient was quite musical in general.

But music and the brain is a special circumstance. Cultures all around the world have specialized music in ceremonies, rituals and among life events, but an alien from outer space might wonder why we humans need to put so much time and substance into hearing, enjoying, learning, performing, and composing music. Somehow and for some reason children exposed to music have in general a superior neural network that is more agile for learning languages and doing well in school. Somehow a famous politician- like some others- was able to recover some of her language function by embarking on a rehabilitation program involving hearing and exposure to some of her earliest childhood tunes and songs.

Somehow various brain regions like the cerebellum that is thought of as the little brain behind the big brain (cerebrum) fires different populations of neurons with connections that are fairly widespread into the deep frontal lobes and areas that fire and release neuropeptides such as dopamine as emotional responses similar to when people are addicted to chocolate, or more poignantly drugs or substance abuse. For some reason when the brain hears music it allows us to transcend everyday mundane experience and experience a noble art form, while allowing our brain itself to forge connections and synapses among various and diverse regions of different neurons and neural networks.

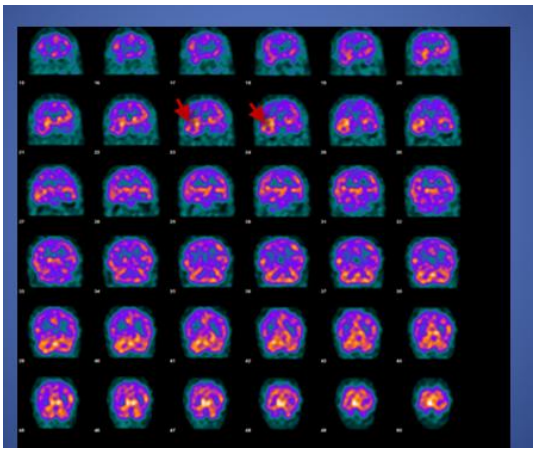

Figure: Ictal Tc-99 SPECT showing relative differences in blood flow and metabolism after creating an ictus from music exposure.

Music, a language of emotions, requires abstract thinking coupled with its mental discipline and the physical coordination of motor skills necessary in playing an instrument. The process must involve multi-layered thinking and complex brain function. Researchers have shown that emotions are a discrete part of intelligence and, contrary to the prevailing belief, emotions are essential to rational thinking. Music often serves as a conduit in various kinds of thought and anatomical activation in the brain. A most challenging aspect for the musician is to understand the intricacies of meaningful data collected from MRI studies and prepare/compose relevant musical examples that would be germane to the subject.

Like each of our senses, we are hard wired as the most sophisticated of super computers would be for receiving the maximal input—we are wired for sound from the teleologically lowest or oldest brain regions in the brain stem all the way up to the most recent and new and or complex brain regions in the cortices bilaterally.

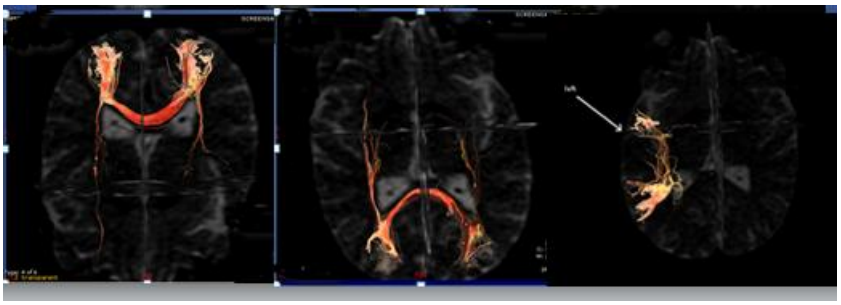

Figure: Showing the use of Diffusion Tensor Imaging (DTI) to map white matter fiber tract bundles using 1.5 T MRI.

What is philosophically intriguing is that not only are sounds itself coded directly onto the cortex itself according to many of the major academic neuroscience research centers, but one can see how performing musicians activate or have major shifts in metabolism or blood flow nearly all over the brain when performing or listening to or thinking about music.

Anecdotally we can find patients who experience clinical phenomena interestingly with regards to music—such as in Oliver Sacks compilation of clinical tales or in the book Musicophilia, but neuroscience and identify that dissonance may exist in certain types of patients with a cortically distributed map or representation of a long latency evoked potential wave form or recorded delayed electrical response of the brain on the surface under certain conditions.

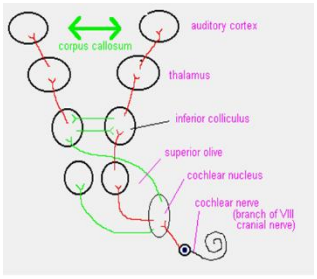

Figure: We are wired for sound, outlining how the neural fiber inputs to the brain generally are targeted.

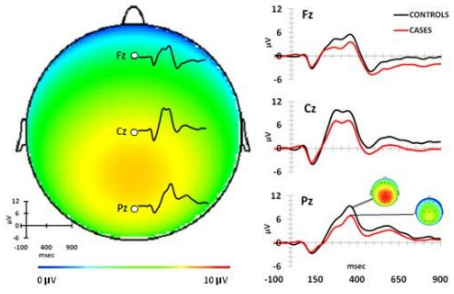

Figure: We are wired for perceiving sound possibly differently. The above is an evoked potential study mapping long latency responses of patients who have mental disorders to control and there may be regional differences in the cortical map of the response corresponding to clinically reported perceptual differences.

Presenting stimuli to the brain and then mapping the subtle changes of the blood flow regionally is the basis of functional MRI neuroimaging, and makes use of the principle that when nerve cells or populations of cells in the brain become active, there is metabolic coupling or activation of blood flow, and the location of such activity can be measured by quantitating this activity (which is the basis of the BOLD response).

How do Mozart or Beethoven type brains come about? And what is unique about their experiences and brains and neural connections and anatomy and physiology that allow them to produce creative works of art of music that become cultural paradigms and iconic compilations of beauty? And why do certain types of addiction and other neural pathways intersect some of these anatomical regions involved teleologically?

What happens in the first few years of life that allow children and trained musicians early on to have such a uniquely wired more musical brain? These are all mystifying questions with basis in a complex neuroanatomy, function, and neurophysiology which we are only at best currently scratching the surface. It is our hope that in studying the neuroscience of music that we will begin to understand these questions and learn much about the brain.

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