Your Brain on Banjo

a Brainjo Production

by Josh Turknett, MD

aboutbrainjo.com

About this Book

Dear Reader,

What follows is a compilation of articles I wrote in a recurring column in the Banjo Newsletter entitled “Your Brain on Banjo.”

The series is about our brain’s remarkable capacity to change itself based on our experiences, and how we can best take advantage of this tremendous resource.

As you’ll discover when reading through these pieces, I firmly believe that anyone is capable of learning to play music well, at any age, simply by applying these principles to their practice.

The truth is, these principles apply to more than just playing the banjo, or even music in general. What’s presented here is a framework for learning that you can apply to virtually anything.

You’re never too old to tackle something new.

Josh Turknett, MD
founder and lead brain hacker, Brainjo Productions

If you’re interested in applying these principles to your own banjo playing, check out my **Breakthrough Banjo Course**, a beginner to advanced methodology based entirely on the Brainjo Method of instruction.

Table of Contents

Your Brain on Banjo: Lessons in Neuroplasticity

An Introduction

by Josh Turknett, MD

Ask somebody how long it takes to learn to play the banjo, and you are likely to get a lot of different opinions. Some might tell you it should take roughly 3 years to play 10 simple songs. Some may say you shouldn't expect to play *Foggy Mountain Breakdown* competently in less than 5.

Others may say it just depends on who you are, and that perhaps some folks just aren't cut out to play the banjo at all. (Or, if they visit the Banjo Hangout much, they might say you can't expect much of anything without a Burlile ring, a sunken wood rim, and cryogenic strings).

My brother-in-law, when he decided to take up the guitar, was told by his instructor he'd be making "real music" in about 2 years. Not surprisingly, he quit after a few lessons.

But, then again, we have all heard the occasional story, or seen the occasional player who, after perhaps a year or less, is jamming confidently with others, maybe playing *Foggy Mountain Breakdown* cleanly and up to speed, possibly even playing in a full time band or winning banjo contests. What are we to make of this?

Most folks consider these examples to be anomalous, not appropriate to be used as any basis for comparison. The conventional wisdom is that they are blessed with a rare, innate talent, that they have won some genetic lottery, and prodigious musical ability is simply encoded in their DNA.

But is this really true? Are we to believe our banjo playing fate is predetermined in our genome, that there exist a select few "naturally talented" individuals able to pick up the banjo quickly, while the rest of us are condemned to 10,000 repetitions of the forward roll before we can eek out a passable version of *Cripple Creek* at our twenty eighth slow jam?

To try to answer this question, I'd suggest we go straight to the source of our banjo playing ability...our brains.

No New Tricks for Old Dogs?

For centuries in the field of neurology, the prevailing view was that during childhood the developing human brain is in a constant state of flux, wiring and rewiring itself in response to the shifting demands of human development as we learn to walk, talk, ride a bike, throw a ball, etc.

During this period of growth, the brain is "plastic", capable of molding itself into what it needs to become. When you think about it, this is truly an amazing thing. Inside our skull sits a machine that can re-engineer itself!

But, as the story went, this capacity for rapid adaptation is short lived, as it slows down during adolescence, and by adulthood sadly grinds to a halt. Neuroplasticity is a gift given only to the young. And so, if you want to learn a new skill, you had better do so as a child, while your brain is still capable of the requisite change.

As you might expect, this view had important implications for adults who had suffered neurologic injury, such as stroke. The party line was that if you are going to suffer a brain injury, it is best that it too happens while you are still young, while your brain is still capable of adapting to it.

In fact, there are incredible accounts of children who, after having had roughly half of their brains removed (as treatment for a rare disease), ended up developing into normal adults.

But if you are an adult, forget about it. Once the brain of an adult is injured, that's it. There is little capacity for adaptation and change in the adult brain, so little sense in trying to change it.

Rehabilitation of brain injury then focused on doing the best with what you still had, and not on trying to regain what you had lost. Because once it was lost, it was lost forever...

Or so we thought.

The Neuroplasticity Revolution

In the early 1990s, a neuroscientist by the name of Edward Taub began conducting a series of a intriguing experiments to investigate a new method for stroke rehabilitation. In these experiments, he would take stroke patients who, as a result of their stroke, had lost significant use of one of their arms.

Now typically in this situation, as mentioned earlier, rehabilitation would focus on teaching these patients how to adapt to life with one arm. Trying to regain function in a paralyzed arm would be an exercise in futility.

After all, much of the part of the brain that controlled the weakened arm was dead due to the stroke. To be able to use it again would require the formation of new connections to that arm from the brain, a feat that would require a massive amount of neural reorganization.

And, since these were adults, such change was not thought to be possible. But Dr. Taub, not wanting to believe the status quo, and buoyed by other emerging research on neuroplasticity (including his own), tried something radical.

Over a period of two weeks, he would take these patient's good arm, and, for 90% of the day, immobilize it in a sling, forcing them to do everything with their weakened arm. Additionally, during these two weeks, they spent several hours each day performing various motor tasks (putting pegs in pegboard, picking up pennies, etc.) with their weak arms.

As they improved, they were assigned harder tasks. And, what he was able to show was that in the span of just two weeks, not only did they improve, but they improved substantially. Patients who had for years been dependent on others to do even the simplest of things were now able to reclaim their independence.

As you might expect, Dr. Taub's initial results were met with great skepticism in the neuroscience community, as this type of recovery wasn't supposed to be possible. But time and again the results of this treatment have been replicated. And further studies have shown that alongside this improvement in arm function, as might be expected, is an expansion in the amount of brain space devoted to the weakened arm.

In fact, the amount of brain sending signals to the arm almost doubles after this therapy! So here we have clear cut evidence for massive reorganization of an adult brain, and after a mere 2 weeks! And, even if these patients have no further therapy for the ensuing 2 years, these brain changes still largely persist. So the changes not only happen fast, but they are lasting.

Because of its therapeutic implications, the field of neuroplasticity has, not surprisingly, become an area of intense research over the past couple of decades. The results of this research has forced those of us in the neuroscience community to completely re-examine our notions about the brain's capacity for adaptation.

And the picture that continues to emerge is not of a brain that is only capable of adapting and changing during childhood and adolescence, but rather of a brain that remains capable of continual adaptation and reorganization throughout our lives.

So, you might ask, what in the world does all this have to do with learning the banjo?

Well, as it turns out, quite a bit. In order for us to acquire a new skill, our brains must change. The more complex the skill, the more change that must occur.

Most of you can probably remember how awkward it felt the first time you tried to pick a simple inside out roll with your picking hand, or wear finger picks for the first time, or finger your first D chord. Despite your best efforts, your fingers didn't want to listen.

Learning to play the banjo at that time may have seemed like an insurmountable task. But, slowly but surely, things got easier. You may have even found that one day that D chord seemed almost magically easier to fret. What was once awkward ultimately became comfortable, almost second nature.

This phenomenon is often referred to as "muscle memory" - i.e. your muscles are finally "remembering" what to do. This term is a bit misleading though, as what really happens has nothing to do with our muscles, and everything to do with our brains.

What actually happens each time we learn one of these skills is that a complex network of connections is formed among the neurons (or nerve cells) in our brain, the final result of which is a finely orchestrated signal from our brains to our muscles, precisely telling which ones to contract and relax, and in what sequence.

Such a network of nerve cells devoted to a certain function is usually referred to as a "neural network". And so, if you've mastered the aforementioned skills, you now possess a neural network telling your fingers how to perform an inside out roll, how to best move your fingers with picks on, and which muscles in your forearm need to contract so that your fingers can fret a nice, clean D chord. This is plasticity in action!

Each new skill we learn on the banjo, from executing a pull off to the entire sequence of left and right hand movements for *Foggy Mountain Breakdown*, requires the formation of a new neural network. That first time you went to finger a D chord, your brain had no such network, which is why it felt so awkward!

For some, this awkwardness can be a source of immense frustration, as they wonder how something that seems to come so easily for some folks seems so incredibly difficult to them. But, in reality, none of us are born knowing how to do these things. None of us are born with a “forward reverse roll” neural network already wired into our brains. All of these networks must be built. And they are built, in all of us, through practice!

So getting back to our original question, how long should we expect it to take to learn to play the banjo, or any musical instrument, for that matter?

Well, if creating new neural networks is the name of the game, then the answer should rest entirely on how long it takes to build banjo playing neural networks. And while we cannot provide a precise answer, based on research thus far on brain plasticity, we can build these networks much faster, and on a much greater scale, than previously thought.

And what now can we make of those folks who seem to pick things up so easily, who seem as if they are simply "born" to play the banjo?

Well, as you might expect, what really separates them from the rest of us is that they have taken advantage of their brain's plasticity. Their rapid progression is not the result of some superior, innate, musical aptitude, but rather the result of their superior utilization of their brain's capacity for adaptation.

While innate aptitude may play a small role in the development of musical expertise, the main reason these folks have developed so quickly is that they have discovered for themselves how to practice in ways that promote the rapid formation of high quality banjo playing neural networks.

And what is most important to the rest of us is that this ability to change our brains is not something only a select few of us possess, and it is not a gift only the young are blessed with. It is something we all possess, and it persists throughout our lives. And so how quickly and how well you learn to play banjo is not determined by the brain you are born with, **it is determined by how you go about changing the brain you have**.

Bringing the Revolution to the 5 string

A revolution has occurred in our understanding of the adaptive capacity of the human brain - a revolution that has broad implications for folks learning to play musical instruments...even the banjo! And thanks to the growing body of research spurred on by this revolution, we are learning more and more about how we can make the most of our brain's plasticity.

In the upcoming "Your Brain on Banjo" series of articles, we will be discussing the latest research in this rapidly evolving field, and translating it into a practical guide for how you, just like those "naturally talented" folks, can take full advantage of your wonderfully plastic brain.

Your Brain on Banjo: Lessons in Neuroplasticity

Baby Steps

by Josh Turknett, MD

As you sit there in your easy chair breathlessly leafing through the pages of your shiny new *Banjo Newsletter* with one hand while grabbing one potato chip after another out of the bag with the other, you probably don't think there is anything special about what you are doing.

In fact, you have no trouble at all comprehending the words printed on these pages while your hands are engaged in other pursuits. But, then again, turning the pages of a magazine or grabbing a potato chip is easy, right? Playing *Dear Old Dixie* up to speed, on the other hand, now that's hard!

Well, as anyone who has watched a 7 month old struggling to pick up their first cheerio can attest, things were not always so easy. In fact, as we discussed in the introduction to this series, every motor skill we develop requires the formation of a new neural network within our brains.

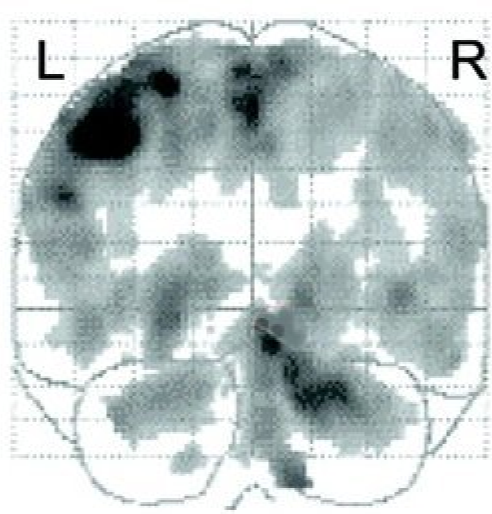
This is true for all of us at any stage of our lives, whether it is when we are trying to pick up our first cheerio, or trying to form our first C chord on the banjo. Eventually, during the first few years of our lives, we built quite a few neural networks, and now all those things that at one point seemed nearly impossible can now be performed automatically.

Our Brain on Autopilot

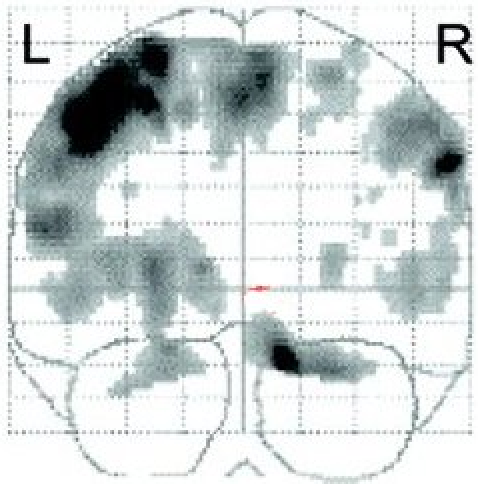
Thanks to advances in functional brain imaging, recent research on this phenomenon of "automaticity" is starting to shed some light on what happens in our brains when a skill goes from being novel and difficult to familiar and automatic.

Within the context of this research, *automaticity* for a task is said to be present when a secondary task can be performed with minimal interference - in other words, the execution of the automatic task is not significantly impaired by the simultaneous performance of another task.

In a 2004 study in the *Journal of Neurophysiology*, subjects were asked to learn a 12 step sequence of finger movements (not unlike banjo rolls!). Below is a picture of the brain activity (in cross section) during the finger movements early in the learning process, before automaticity has developed (the darker the shade of gray, the greater the activation):



After this initial brain scan was taken, the subjects then practiced the task for several hours until it became automatic. Automaticity was tested by having the subjects perform a letter counting task while executing the finger movement sequence. Once they were able to execute the finger sequence just as quickly and accurately while simultaneously counting letters as they could while performing it without distraction (thus fulfilling the requirement for automaticity), their brains were imaged again during the finger movement sequence, and the results are below:



As you can see, once the task has become automatic, less of the brain is being activated. It has also been demonstrated in subsequent studies that, accompanying this reduction in activity is a *strengthening* of the connections between the areas that remain active.

Furthermore, there is also a significant *decrease* in activation in parts of the brain involved with attention and information gathering. Thus, **when a skill becomes automatic, it not only requires less brain activity, but it also frees up areas of our brain involved in attention and information gathering**.

So why is this important? Well, consider all the things you must keep track of during a typical jam.

There is the song itself, the key and chord progression, the tempo, the melody, the chord being played at the moment, the lyrics if you are singing, the tone and volume of your banjo (yes, you *should* be keeping track of this!), who is soloing and what instrument they are playing, how vigorously to shake your head no when it is your time to solo, etc.

With all that to keep track of, who can blame us for drooling! And so, as has just been shown, if your brain still has to devote all its resources to that first forward roll in *Foggy Mountain Breakdown*, then it is *biologically impossible* for it to keep track of all that other stuff. And the result is...meltdown!

But, as this research illustrates, meltdown in this situation is not the result of some sort of inferior musical ability, as many might conclude, but rather the result of us placing unrealistic demands upon our brains.

Preventing Meltdown

So, then, how can we avoid meltdown? How can we help ensure that our brain is able to pay attention to everything it needs to, that its attentional resources aren't being monopolized by the technical components of banjo playing?

Well, the key, of course, is to make sure that the technical aspects of playing, the right and left hand skills, have become automatic. Because as we now know, if they have become automatic then we have developed efficient neural networks devoted to their execution - networks that require less of our brains, and less of our brain's attentional resources.

The acquisition of the technical skills of banjo playing can be viewed as a cumulative process, with increasingly complex skills being built on top of simpler ones; and relatedly, with increasingly complex neural networks built upon simpler ones.

With this in mind, it should be clear that we shouldn't move on to a more complex skill until we have mastered the simpler ones it is built upon - until they have become *automatic*. For example, we should not attempt to learn the first measure of *Foggy Mountain Breakdown* until we are able to cleanly pick the strings with our right hand, cleanly fret a note, perform a hammer on, and perform a forward roll *automatically*, since the neural network we build for *Foggy Mountain Breakdown* will require all of these foundational networks to be firmly established.

And how can you determine whether a skill has become automatic? Well, just as was done in the research studies, if you are able to execute these techniques well while your attention is diverted elsewhere (watching TV, reading the BNL, playing with a metronome), then they have become automatic.

And while mastering one skill at a time might seem like a tedious and slow process, the irony is that by doing so you will progress towards becoming a complete banjo player much faster than you would if, in your haste to learn everything, you try to acquire too many new skills at the same time.

In fact, many folks, particularly adults, in their rush to get better end up developing sloppy, inefficient banjo playing neural networks - a house of cards prone to collapse under the slightest pressure.

Of course, back when we were trying to grab that first cheerio, we all did this instinctively. Virtually every human being passes through the same exact sequence of motor development during infancy, mastering one skill at a time with an almost pathological obsessiveness, gradually adding skills of increasing complexity once the ones they are built upon have been mastered.

The sequence is predictable, methodical, and remarkably efficient and effective, as Mother Nature can't afford to leave this process to chance.

As a result, most all of us end up becoming expert potato chip grabbers and magazine page flippers. Follow the example of the developing infant, and you will undoubtedly become an expert picker and grinner as well.

Your Brain on Banjo: Lessons in Neuroplasticity

Don't Monkey with Your Brain!

by Josh Turknett, MD

Practice makes perfect.

We have all likely heard that phrase many times in our lives, perhaps initially when trying to hit our first baseball, tie our first pair of sneakers, or ride our first bike. And surely all of us know by now that we will not get better at anything unless we practice at it. Skills must be learned - they are not just bestowed upon us out of thin air.

But practice hard, we are told, and these skills will come. So we banjo players diligently put in our time each day repeating our forward rolls and bum ditties, confident in the value of practice.

But is that enough? Is reaching our musical goals simply a matter of logging so many hours of practice time? Our experience tells us this cannot be the whole story, that there must be some other factor.

After all, how is it that different folks, practicing the same material for the same amount of time, can achieve such different levels of success? That's talent, of course. Or so they say.

So where can we look to see what brain science has to say about this matter? To monkeys with webbed fingers, of course!

Plasticity - Use at Your Own Risk

In 1991, Michael Merzenich, a scientist and pioneer in the field of plasticity research, and his colleagues, conducted an intriguing experiment. Though this was only two decades ago, at the time our attitudes about the adaptability of the brain of an adult primate were still much different. As discussed in previous articles, it was widely held then that there was little capacity for large scale change.

Dr. Merzenich, not entirely convinced of this, decided to study the capacity for adaptation in the somatosensory cortex (SSCX), a part of the brain involved in the processing of sensation. Here is how it works - each time the surface of our skin is stimulated, a nerve impulse is generated within the nerve ending inside the skin.

This impulse then travels upwards along tracts of nerve fibers in our extremities, up through the spinal cord, ultimately terminating in the brain's somatosensory cortex, at which time it registers in our consciousness that something has touched us. And within this region of the brain there exists a sensory "map", such that nerve impulses originating from adjacent portions of our skin terminate in adjacent portions of the SSCX.

Prior to this experiment, it was thought that these sensory maps in the brain developed very early in our development, and were pretty much set in stone after that, not subject to change.

In his experiment, Dr. Merzenich, using a group of owl monkeys, first mapped out the representation of the 3rd and 4th fingers in their brains. To do so, he would stimulate the skin of their fingers using a tiny hair, and, using microelectrodes implanted in the brain, record where in the SSCX these impulses terminated.

As expected, the impulses from the skin of each individual finger terminated in a discrete area of the brain, such that the area of the brain receiving impulses from the skin of one finger received no impulses from the skin of the neighboring one. Then, after this baseline sensory map was created for each monkey, he attached their 3rd and 4th fingers together, creating a single webbed finger.

At first, life with the webbed finger was a bit difficult, but after a relatively short period of time the monkeys were able to skillfully use their newly webbed finger. Several months later, after first separating the webbed digits, Dr. Merzenich then set out to determine what, if any, changes had occurred in the sensory maps in the brains of these monkeys.

Remember, conventional wisdom at the time was that nothing at all should happen, since primate brains weren't supposed to change after early childhood. So, using the same procedure as described above, he once again created a sensory map for each of the monkeys's hands.

What he found was extraordinary. These maps were not like the previous ones at all, as the representations for the 3rd and 4th digits had now fused into one! Just as there no longer existed any physical separation between the 3rd and 4th fingers on the monkeys' hands, there no longer existed any separation between the sensory maps for these fingers in their brains.

The brain had changed itself to more accurately represent this a new physical reality. Webbing the fingers had also webbed their representations in the brain! As a result, even after the fingers were no longer attached, the monkeys could no longer clearly distinguish between a touch on their 3rd finger and one on their 4th. And in order for them to once again be able to clearly distinguish between a touch on the 3rd or 4th finger, their old sensory maps would have to be reformed again.

Besides providing us with a striking, and, at the time, paradigm challenging example of brain plasticity, this experiment also presents a cautionary tale. When tapping into our brain's plasticity, we must proceed with caution.

Let's consider the following example.

The Sad Tale of Hasty Hank

Hank, an aspiring scruggsophile, decides it is about time he hunkers down and learns *Fireball Mail*. Just like Earl did it, of course.

Hank has a good ear and a good set of basic skills, and is able to learn the down the neck part with relative ease. He can play it up to speed, and it is sounding good. However, as he then tries to tackle the up the neck variation, he begins to struggle a bit.

In particular, there are two measures he has difficulty fretting cleanly and playing in time. But, not wanting to bring his practice session to a screeching halt just for two lousy measures, he continues playing the tune at close to full speed, flubbing his way through those two measures each time. After all, he thinks, practice makes perfect, and so he is confident that all this time and energy will pay off in the end.

The next day he comes back to the tune, and to his disappointment things are no better. Expletives and picks fly as he starts to doubt his potential as a banjo player and his value to society. After regaining his composure, he starts up again.

And he continues like this, day in and day out, practicing the tune, but never really taking the time to get those two measures right. And each day those mistakes in the up the neck part are still there. In fact, it almost seems as if the mistakes just play themselves, as if he is now incapable of playing the tune without them.

Eventually he gives up, resigning himself to the apparent fact that he is just not ready for this tune yet. "If only I were more talented", he thinks to himself.

I'll bet most of you have experienced something like the aforementioned scenario at some point in your journey. And we have all felt how hard it is to remove a mistake once we have learned it. **Harder, in fact, than learning things right the first time**.

But, given what we know about monkeys with webbed fingers, this should come as no surprise. Provided with input day after day that made it seem as if their 3rd and 4th fingers were now one, the monkey brains reorganized to represent them as such. And even after their physical separation, they remained represented as one in their brains.

In order to re-adapt to life without webbed fingers, they now had to erase the sensory map of the webbed finger, and recreate the old one with the individual digits cleanly separated. Thanks to plasticity, this can happen - but it takes time.

Likewise, Hank, while trying to learn the up the neck part of *Fireball Mail*, provided his brain with the same input day in and day out - input that included the sloppy fingering. So it should come as no surprise that his brain created a *Fireball Mail* neural network with the sloppy fingering embedded right in it.

That is what he told his brain he wanted, and his brain delivered. Now, every time he sits down to play it, his brain sets the neural network in motion, mercilessly repeating that same mistake to the detriment of Hank's self confidence.

Prodigious and Patient Pete

Now let's consider the example of Patient Pete. Pete is also a budding 3 finger enthusiast and has been playing about as long as Hank. He too decides it is time to tackle *Fireball Mail*, and he too initially struggles with those same two measures.

But Pete, who also happens to be a longtime subscriber to *Webbed Monkey Fingers Weekly*, decides he must get those two measures right, whatever it takes. And so, in spite of the desperate protestations of his wife and family, *the only* thing Pete practices for the next two days are those two measures. And each time he does so, he plays them through slow enough to play them mistake free.

Three days later, he plays through the tune with ease, wondering how those two measures that now seem so easy could have ever seemed so hard.

Perfect Practice

Vince Lombardi, renowned coach of the Green Bay Packers, summed all of this up well when he said "Practice does not make perfect. Only perfect practice makes perfect." As we have discussed before, the goal of practice is to create and firmly establish banjo playing neural networks.

And we know all of us are capable of creating these networks, regardless of age, because we all possess brains capable of remarkable change. But they will change in response to whatever input they are given.

And so it is imperative that we, like patient Pete, pay close attention to the input we provide them with, which means playing whatever new thing we are learning as slowly and carefully as it takes to play it perfect.

Give your brain the right input, and you will be amazed at what it, and you, can do. Give it the wrong input, and you, like Hank, may soon be using your 5-string as a doorstop.

Your Brain on Banjo: Lessons in Neuroplasticity

To Sleep, Perchance To Learn Devil's Dream

by Josh Turknett, MD

Ahhhh, sleep, glorious sleep. Few things in this world beat a good night's rest. And few things are worse than a night without it. Yet despite the well documented repercussions of not sleeping enough - memory loss, irritability, weight gain, heart disease, spousal discord, etc. - many of us still do not get the rest our bodies require.

We lead busy lives, after all - there is work to be done, children to care for, errands to run, banjos to pick, ditties to bum, and all night James Bond marathons to watch. It seems there is just not enough time in the day to get it all done and get enough sleep.

So we walk around as bleary eyed zombies, vowing to catch up on our sleep debt sooner or later.

But what if I told you a good night's rest would make you a better banjo picker? What if I told you it might be an *essential* part of making progress on the banjo?

Suddenly that midnight infomercial for the ShamWow just got a little less captivating, eh?

Why Do We Sleep, Anyhow?

You would think that as advanced as we have become in our understanding of human biology, we would have a better grasp by now on something that we spend roughly a third of our lives doing. Yet up until quite recently, we really had no idea what sleep was for.

To us, its *seems* that being asleep is just the opposite of being awake. When we are awake and conscious, our brains are "on" and active, and when we are asleep and unconscious, they are "off" and inactive. So maybe, for whatever reason, our brains just require some off time. Maybe we just need some time to recharge the batteries.

This is certainly a reasonable experience based hypothesis, and as a result has been the prevailing view towards sleep for most of human history.

Thanks to technology that allows us to monitor brain activity while people sleep, we now know the real story is something radically different. The reality is each night our brains pass through a highly orchestrated and predictable sequence of events, with no fewer than 5 discrete stages of sleep, each with its own unique pattern of activity. And our brains cycle through all 5 stages of sleep (only one of which is the well known REM, or dream, sleep) roughly every 90 minutes.

But what is it all for? Certainly it appears that something quite important is taking place - that this complex and stereotyped process serves a critical function. Sure it's fun every now and then to know what it's like to be chased by a giant fire breathing pancake, but hopefully our brains aren't burning precious energy stores just to give us a nightly joyride.

Improving While Sleeping?

I'll bet many of you have encountered the following scenario. You are sitting there practicing some new tune or technique on your banjo, and it just seems impossibly hard. You may work on it for an hour or so, perhaps making some progress, but you still feel like there is a long way to go.

Eventually you realize you are starting to lose focus, so you call it a night and go to bed. The next morning you wake up and grab your banjo, expecting the same frustration. Yet, to your surprise, things are a lot easier. Your fingers almost seem to have a mind of their own, and making them do what you want them to do is no longer a struggle.

It seems almost magical that you could have gotten better without *doing* anything. How in the world could this be possible?

Those of you who have been following this series know that this phenomenon has something to do with neuroplasticity - that during that span of time while you were not practicing your brain was changing itself. But perhaps some of you also have a sneaking suspicion that there is something extra special about sleep.

And if you do, it turns out you are probably right.

Consolidation

Consolidation is the technical term for the process by which a memory (be it what you had for dinner, the capital of Rhode Island, or how to finger an F chord) is stabilized over time. As a result of this process, the memory, along with the neural network encoding it, transitions from being unstable and easily disrupted to stable and resistant to degradation.

Multiple processes occur in the brain (alterations in the strength and efficiency of existing neural connections, formation of new ones, alterations in gene expression, protein synthesis, etc.) to accomplish this transition, processes that occur over various time frames (minutes, hours, days, and likely even longer). And this process of consolidation largely occurs behind the scenes, outside of conscious awareness, working long after you have put down your banjo.

It also happens automatically, whether you want it to or not! So in other words, once you practice *Cripple Creek* for 30 minutes, a whole cascade of neurophysiological events is automatically set in motion that may not reach their full conclusion for several days, or even weeks.

This is why it is so important, as was discussed in the last article on perfect practice, that we make sure we give our brains the right input when we practice, so that the changes it makes are the ones we want.

Research over the past 10 years or so has revealed that a good chunk of this process of memory consolidation occurs *while we're sleeping*. In fact, it appears as if there are parts of the process that may *only* occur during sleep, and perhaps only during particular stages of sleep.

In a 2002 study from the journal *Neuron*, a group of neuroscientists set out to investigate the role that sleep plays in the consolidation process. The study involved a finger tapping task in which subjects were instructed to press a specific 5 digit sequence on a number pad as many times as possible in 30 seconds.

In the training phase of the study, they performed 12 trials, and were scored based on how many times they correctly pressed the 5 digit sequence during each trial.

Subjects were then re-tested after a 12 hour rest period. For half of the subjects, however, those 12 hours occurred over the span of a day, while they were awake; for the other half, the 12 hours occurred overnight, so that the rest period involved a night's sleep. Their performance after 12 hours was then compared to the training phase.

The results? The group that did not sleep performed on average 4% better than they had during the training phase. The group that slept performed a full 20% better - a fivefold improvement over the other group! These results suggest that the brains of the group that slept had changed considerably more than the group that did not over the same span of time.

Furthermore, there was a strong correlation between the amount of improvement amongst subjects who had slept and the time they had spent in stage 2 NREM sleep during the latter part of the night, suggesting that the bulk of the improvement occurred during this particular stage.

Multiple other studies have also demonstrated this same effect, showing that overall motor learning improves significantly more over a period of rest that includes sleep than it does over an equivalent period of rest not including sleep. And it also appears that particular stages of sleep (in this case it was stage 2 sleep, but for other types of learning may be REM sleep, slow wave sleep, etc.) may be *required* for particular types of learning.

Sleep Revisited

While we still have much to learn about why we sleep, it is becoming increasingly clear that it plays a critical role in learning and memory. So critical, in fact, that it may be impossible to learn certain things without sleeping, and perhaps without passing through certain stages of sleep. Both quantity and quality matter in this case.

Altogether, the research suggests that the function of sleep, at least in part, is to give the brain time to review the events of the day and pick out the highlights that it needs to encode, without having to simultaneously parse through the dizzying barrage of sensory data that comes at it during wakefulness.

So it should be clear based on what we know of the learning process and neuroplasticity that our primary aim should not be to get better in the span of a single practice. Rather, our primary goal each time we set about learning something new is to provide our brains the right data to crunch (i.e - "perfect practice") while we are snoozing, and then to give it the rest it needs to do so.
If all goes according to plan, while we are dreaming about playing at the Opry in our underwear, our brains will be busy burning new banjo playing pathways, so that we are a little bit better the *next* time we grab our banjo.

So do yourself a favor - shut off the lights, climb in bed, and turn off that infomercial for spray-on hair. Because while curing male patterned baldness with a can of aerosol paint really is too good to be true, becoming a better banjo player while you sleep is not!

Use the Force, Earl

by Josh Turknett, MD

"*The Force is what gives a Jedi his power. It's an energy field created by all living things. It surrounds us and penetrates us. It binds the galaxy together.*"
- Obi Wan Kenobi

When I was growing up, I wanted nothing more than to be Luke Skywalker. Heck, so did pretty much every other boy my age.

After all, he fought off space aliens with a laser gun and a glowing sword, had his own robots, and had the fate of the galaxy resting on his shoulders. And, to top it all off, he could use the force - that special gift that was the source of a Jedi's power.

Using nothing more than his mind, Luke could hurl objects across the room or even lift a spaceship in the air. What could be more cool?

So I spent many an evening staring at my action figures, focusing all my thoughts on launching them across my bedroom. And...nothing. Nada.

Sure, every now and then I might convince myself I'd seen a flicker of movement, and might even brag about it at the lunch table the next day, but deep down I knew I was fooling myself.

So the years went by and the limitless possibilities of childhood fantasy slowly faded away, taking with it my Jedi aspirations. Changing something in the physical world using nothing more than my mind was just not a realistic goal, I realized. The force, it seemed, would not be with me.

Or would it?

Straight from the realm of science fiction comes this month's *Your Brain on Banjo* column. The topic...**visualization**.

Sound Science or Senseless Psychobabble?

To some of you, the concept of visualization, or mental imagery, may sound a little hokey. Maybe it conjures up the thought of a motivational speaker imploring you to "visualize yourself getting that new job", or you hear Chevy Chase's character in *Caddyshack* telling Danny to just "be the ball".

Surely such new agey gobbledy gook doesn't belong in a column on the serious topics of brain science and banjo pickin', right?

While only a relatively small body of scientific evidence exists on the subject, it turns out that visualization is a remarkably effective tool when it comes to building new neural networks, particularly those involved in the execution of new motor skills.

Neuroscientists began to investigate the effects of visualization on motor skill acquisition towards the end of the 20th century, and the early research clearly demonstrated that the use of mental imagery (imagining yourself performing the new skill) accelerated the acquisition of new motor skills. Subsequently, functional brain imaging studies revealed that when you simply imagine yourself performing a task you activate almost all the same brain areas that you do when you physically execute it.

This then led to another intriguing question - if the same neural networks are activated when you imagine yourself practicing as when you physically practice*, does visualization actually change these networks over time in the* *same way that physical practice does*? Can you actually change your brain's structure just by thinking about something?

Plastic Brained Pianists

In 1995, neuroscientist and plasticity pioneer Alvaro Pascual-Leone set up an experiment to try to answer that question. In the study, subjects were divided into three groups. On day one, each group was taught a one-handed, five-finger exercise on the piano (none of the subjects had any prior piano experience).

The first "physical practice" group then practiced the exercise for two hours each day along with a metronome for five consecutive days.

The second "mental practice" group also sat at the piano for two hours each day (like group one), but were only allowed to VISUALIZE themselves playing the exercise. They pressed no piano keys, and in fact were not even allowed to make any kind of movements with their hands.

The third group, used as a control, did not practice at all after day one. Then, on day five, each group was tested and scored on both accuracy and timing.

On the fifth day, both the physical and mental practice group had improved considerably on both measures. The physical practice group performed best; however, the mental practice group was not far behind. The group that did not practice did not improve.

Albeit impressive, these results were not particularly surprising at the time, as visualization had already been shown to be an effective tool for motor skill learning. What was remarkable, however, was what had happened in the brains of these subjects.

Using a technique called transcranial magnetic stimulation (TMS), the investigators discovered that, in both the physical and mental practice groups, the cortical representation of the muscles involved in piano playing had expanded markedly from the start to the end of the experiment. Over the course of just 5 days, the area of brain tissue in primary motor cortex sending signals to these muscles was now roughly **nine times larger**.

And the degree of expansion was the *same* in both groups. Virtually the same structural and functional alterations had occurred in piano playing neural networks regardless of whether the activity was practiced physically or mentally.

By doing nothing more than thinking about piano playing, the subjects had changed their brains.

Pretty incredible, huh? So let's get this straight. In the last column I talked about getting better at banjo pickin' by sleeping. Now I'm saying you can get better just by thinking about playing the banjo. Have we eliminated the need to play an actual banjo?!

In all seriousness, while there are elements of banjo playing that cannot be replicated by mental imagery, it can be a helpful addition to the learning process. And if like me you sometimes struggle to find enough time to practice between the demands of work and family, you will appreciate the chance to squeeze in some extra practice time (next you must master the art of visualizing while pretending to do something else - essential for keeping those work and family responsibilities intact!).

Besides, most of us spend most of our time daydreaming about pickin' anyways - might as well be productive about it!

Putting Thoughts into Action

If you have never tried visualization at all before, it may take a little getting used to. Some folks when told to imagine themselves doing something may imagine *watching* themselves doing it, which is not the idea. You should visualize in first person.

In other words, you should *feel* yourself performing the imagined activity. To help get the idea, try the following exercise - visualize yourself signing your name with your dominant hand (i.e. - right hand for right handers, left for lefties). It should feel smooth and effortless.

Now imagine yourself signing your name with your non-dominant hand (feel yourself holding the pen, placing it on the paper, etc.). If you are visualizing correctly, this should *feel* terribly awkward. If it does, then you've got the idea.

There are many ways to put this to use. You could simply visualize yourself playing a typical practice session from start to finish. However, I've personally found it helpful in developing specific skills, particularly ones that seem especially awkward at first, including:

- **Three finger rolls** - for the beginner, this is a great way to help burn those awkward roll patterns (forward backward, inside-out, etc.) into your "muscle memory".

- **The bum ditty, etc.** - every clawhammerist knows just how awkward the basic frailing stroke is at first. More advanced techniques like drop and double thumbing also work well.

- **Difficult sections** - even the most advanced player will encounter tunes where there is a section involving some difficult picking - perhaps an unusal picking pattern or some intricate left hand fingering. Visualize yourself playing the section slowly and perfectly.

- **Chord shapes and chord changes** - we all know how impossible these seem at first!

- **Advanced left handed clawhammer techniques** - the alternate string hammer and its evil cousin the alternate string pull-off both involve some tricky timing between the right and left hand, which visualization can help solidify.

- **Memorization**. Visualization is a fantastic tool for memorizing a new tune. This can be particularly helpful for those of you who are learning primarily from tab, where memorization is often more of a challenge.

As an added benefit, when you memorize through visualization your brain will also start creating pathways that map sound to fretboard positions and picking patterns - connections that are critical for learning to play by ear and improvise. Just be sure you are visualizing the actual movements of your hands (and hearing the notes as you do it), and not visualizing yourself staring at a sheet of tab!

As we have discussed previously, every skill or technique that is part of playing the banjo requires the formation of a new neural network in our brain. Awkwardness results when no such network exists yet.

We form these networks through practice, and are able to do so thanks to our brain's remarkable plasticity. Visualization can thus be viewed as another means of building these networks - an adjunct to physical practice that can help you achieve your goals faster and more easily.

And, for those of you who like me had all but given up on those childhood fantasies of wielding the force, of being able to alter something in the physical world through thought alone, I say to you, in the immortal words of Obi-Wan Kenobi:

May the force be with you....always.

The Dangers of Distracted Picking

by Josh Turknett, MD

Imagine the following scene. You're driving home from work at your usual hour. It is a drive you have made hundreds, perhaps thousands, of times. You know it by heart, and could do it with your eyes closed. It is so routine that on a typical day you arrive home with little memory of the events that transpired on that drive.

Some days your recollection is so scant you may even wonder how the heck you made it home, a well known phenomenon dubbed "highway hypnosis". But this day is different. This time, as you are pulling through a busy intersection, an eighteen wheeler, its driver busy text messaging, speeds through his red light from the opposite direction. He's coming straight at you.

You hit the gas. The truck barely misses you, instead slamming into the passenger side of the minivan behind you. The van flips multiple times. Fire begins to emerge from beneath the hood. You stop your car, rush to the scene and find a woman trapped in the front seat.

She's breathing but unconscious. Her baby is in the carseat in the back, awake and crying. You hop in, extricate the child and the woman from the van just before the vehicle is completely engulfed in flames.

It goes without saying that this is not one of those drives home you will soon forget. In fact, from this day on you will likely remember everything about that drive - not just the accident itself, but other details like the day of the week it occurred, the clothes you were wearing, the weather outside, etc.

These details that would typically be as fleeting as yesterday's breakfast are now forever etched in your memory. But why exactly is that? How do our brains decide what is worth remembering…and what isn't?

The Gatekeeper of Plasticity

One of the realities our brain faces is the fact that it only has a fixed amount of space within which it can store information. Now, our brains are really, really good at cramming an incredible amount of information into that space, but, as with all things finite, there is a limit to its storage capacity. And there's a limit to its plasticity.

Furthermore, changing the brain requires energy - energy that our bodies do not like to waste. So it makes sense that there would be mechanisms in place to ensure that this space and energy is used wisely. And it is becoming increasingly clear that one of those mechanisms is *attention*.

At any given moment our brains are bombarded with a constant array of stimuli. Just sitting at my kitchen table typing this article there are multiple things vying for my attention. There are the roughly 30 separate objects in my visual field, the sounds of my kids playing in the background, the hum of the refrigerator, the touch of the chair on my legs, the itch that needs scratching on my shoulder blade, etc.

Yet somehow, in spite of all of these potential distractions, this cornucopia of sensory data, I remain focused (well, pretty much!) on the task of typing this sentence into my computer. My brain manages to filter out the extraneous sensory data and bring the task at hand to the foreground - no small feat of cognition.

As with most networks underlying cognitive functions, the ones that support attention are distributed across multiple brain regions. One of these regions is the basal forebrain, a structure that sits, naturally, at the bottom front of our brains and plays an integral role in attentional networks. Within this region are neurons that project to all areas of the cerebral cortex and release the neurotransmitter Acetycholine into their synapses.

With such widespread connectivity, this group of "cholinergic" neurons appears well placed to influence processes throughout the brain. Based on several lines of converging evidence, the emerging view is that they function as the brain's gatekeepers of learning and, more specifically, plasticity.

One such line of evidence comes from studies on motor learning in humans in where subjects are given substances that either disrupt or enhance the function of these networks. In a 2001 study in the *Journal of Neurophysiology*, subjects were given Scopolamine, a drug that blocks the receptors for Acetylcholine, or a placebo, during a motor learning task involving thumb movements.

Using transcranial magnetic stimulation, a technique used to non-invasively stimulate the brain, changes in the thumb region of primary motor cortex were investigated after training. What they found was that the motor cortex of subjects who had trained while Scopolamine was in their system had changed little in comparison to the changes that had occurred in the motor cortex of the placebo group.

Blocking the action of Acetycholine had stunted plasticity. Similarly, the same experiment was later performed using the drug Tacrine, a compound that increases the availability of Acetylcholine in the brain. In this case, subjects who trained with Tacrine in their system actually had greater reorganization in their motor cortex following training than those who had received placebo.

Increasing the availability of Acetylcholine had enhanced plasticity.

At the very least, these experiments support the notion that the neurotransmitter Acetylcholine is a critical component in motor plasticity. However, more selective studies on animals suggest that it is specifically the Acetylcholine from those neurons in the basal forebrain we have discussed that are critical.

In a 2003 study in the journal *Neuron* using rats, these particular cholinergic neurons from the basal forebrain were selectively destroyed. The rats were then trained on a novel skill involving one of their forelimbs (retrieving food pellets from a hole in a plexiglass box).

Contrary to normal-brained controls, the rats without this group of neurons were significantly impaired in their ability to learn the new skill. Furthermore, while there was considerable expansion of the area in motor cortex representing the trained limb in the normal rats after training, there was no such expansion in the lesioned rats.

Destroying the cholinergic neurons in the basal forebrain had prevented skill learning, and relatedly had prevented brain remodeling, or plasticity, in response to training.

Remembering the Drive

Okay, rat brains, Acetycholine, basal forebrain…what does any of this have to do with banjo pickin?! Well, those of you who have been reading this article series know that the business of learning the banjo is really the business of changing brains, of creating new banjo playing neural networks through practice. It is about utilizing your brain's remarkable ability to adapt and reorganize itself - its *plasticity*.

But our brain doesn't just change itself willy nilly, as evidenced by the experiments above. There are safeguards on the mechanisms of plasticity to prevent this. And one of those safeguards appear to be these cholinergic neurons from the basal forebrain, neurons we know to be an integral component of our attentional networks.

So if we want our brains to change after we practice, we want to be make sure that while we practice these neurons that function as the gatekeepers of neuroplasticity are active, flooding their synaptic terminals in motor cortex with Acetylcholine. And how can we make sure this happens? Easy. We can **pay attention**!

Making sure we pay attention when we practice may seem like a childishly simple idea, but in our modern era where multitasking has become our default mode of operation, it bears repeating. The world today is riddled with potential distractions - distractions that in the digital age seem to be growing exponentially. As such, it is become less and less common for us to spend extended periods of time with single minded focus on a single task.

But it is clear this type of extended focus is vital for learning and plasticity - it is how we signal our brains that what we are doing is worthwhile. Worthwhile enough to remember later.

Events that represent a threat to life, like a fast approaching eighteen wheeler, instinctively and subconsciously monopolize all of our attentional resources, as the price of distraction could be death. Not surprisingly, for the reasons discussed above, these events are burned into our memory banks.

But otherwise, it is up to us to consciously control our attention and concentration, to turn off the distractions of our modern lives, engage our attentional networks, and tell our brains that this journey is worth remembering.

Your Brain on Banjo: Lessons in Neuroplasticity

The Talent Myth

by Josh Turknett, MD

Back while I was in college, I took a course called "Worlds of Music," where we studied traditional music from around the globe. One morning during his lecture, our professor played a recording that had been made by James Koetting, an ethnomusicologist studying traditional African music.

The recording was the sound of four workers in a post office in Ghana as they went about canceling stamps. Sounds mundane, right? Yet without this backstory, we wouldn't have had any idea we weren't listening to a highly rehearsed musical "performance."

There were no musical instruments involved, just the sounds of the postal workers doing their job -- two workers bring a the letter from a file, slapping it a few times for effect before inking the marker and then stamping the letter. A third worker clicks along with a pair of scissors. Together, these three produce an intricate, complex rhythm, while a fourth worker whistles a melody over the top of it all. The end result is jaw dropping.

Our professor told us that the workers themselves were somewhat puzzled by the attention they were receiving from Dr. Koetting. They couldn't understand why he was so interested in what they were doing because they didn't think there was anything special about it. What seemed extraordinary to an outside observer was entirely ordinary to them.

To me and my classmates who were listening, we found this unbelievable...and eye opening. Clearly the relationship these people had to music was much different than those of us in the class that day.

In Ghana, not only is music inextricably woven into the fabric of everyday life, but everyone participates in it. No distinctions are made between the musical and the unmusical. It is taken as a given that every child born into that culture will learn to make music, and make it well.

Born Naturals?

In the Western world, our notions about music -- and a great many other things -- are intimately intertwined with the limiting concept of innate ability. Kids have barely learned to talk before we're trying to determine if they're "naturally" good at solving puzzles, drawing pictures, or kicking soccer balls. How many times have you heard phrases like these:

"Johnny is a great baseball player, he gets it from his father" or

"Sally is a wonderful artist. She's just so gifted" or

"Oh, I'd love to play the banjo, but I don't have a musical bone in my body"

Implicit in this type of language is the idea that ability, including the capacity to make music, is innate. In other words, we're endowed with our own unique set of talents from birth, bestowed upon us by the DNA we inherit from our parents.

If we're lucky enough to be born with musical ability, then we can learn to play music. If not, then we should probably pursue something that we're "good at," regardless if that's where our heart is. But, is there any truth to this notion of talent?

When Passion Meets Opportunity

In the book *Outliers*, author Malcolm Gladwell examines the stories of people who've reached the pinnacle of their fields of expertise, looking for the factors that lead to extraordinary achievement. What he finds common to all their stories, from great athletes to technological innovators, are two things: a passion for what they do and opportunities to nurture it.

What he does not find are stories of people whose inborn talent propelled them inexorably to the heights of achievement. For example, Bill Gates became a pioneer in computing not because he was smarter than everybody else, but because he was both obsessed with computers AND as a teenager had unprecedented access to computing resources where he could feed that obsession.

If you doubt that the same applies to music, consider the following study, discussed in Daniel Levitin's book *Your Brain on Music*. In the study, teachers at a music conservatory were asked to secretly rate their youngest students according to their musical "talent."

Years later, the researchers went back to look at how well these initial ratings correlated to those students' eventual musical achievement. Guess what they found? Nothing. The students' talent rating when they were first starting conservatory did not predict their eventual musical expertise at all.

What did predict who became expert musicians? Practice. Those who practiced more, and practiced *better*, regardless of their initial "talent" rating, were the ones who excelled. Similarly, retrospective studies of concert pianists and violinists reveal that, when first beginning their lives in music, they were no more likely than their peers to show any particular musical "talent."

Incidentally, you don't need to look any further than the pages of the *Banjo Newsletter* to see this for yourself. There's a common thread running through nearly all of the stories of the great banjoists we read about here each month, and that is of someone who finds a passion for music and the banjo and then relentlessly pursues their musical ambitions.

What we don't read are stories of individuals with prodigious talents manifest at an early age who rise effortlessly to the heights of musical expertise.

The Brain You Make

Even scientists haven't been immune to this cultural bias about innate ability, including those who study the brain. For decades, neuroscientists believed that the brain was fixed after development, incapable of further change and adaptation -- a belief reinforced by the widely accepted idea in broader society that abilities were innate.

We now know that the human brain retains its capacity for adaptation and change throughout our lives, and it is for this reason that, even if innate talents or predispositions exist at all, they end up virtually irrelevant in the final analysis.

As I've tried to emphasize in this "Your Brain on Banjo" article series, your success in achieving your musical goals is determined not by the brain you are born with, but by the brain you create through quality practice.

It is not determined by inborn traits possessed by just a select few, but by the biological properties of the human brain that we all share.

When stagnation occurs in our musical development, it isn't because we lack the DNA needed to progress, but because we fail to exploit the mechanisms of neuroplasticity that support learning (and for more on how to do so, see prior and upcoming installments of “Your Brain on Banjo”).

It's a wonderful time to be a banjo player. With the unprecedented amount of learning resources we now have access to, there's nothing standing between us and our musical ambitions but the will to reach them. So practice hard, practice smart, and never buy into the myth that you don't have what it takes.

Your Brain on Banjo: Lessons in Neuroplasticity

Neuroanatomy of a Banjo Jam

by Josh Turknett, MD

It is the crowning achievement of biological evolution, a machine so powerful and sophisticated we have only just begun to understand its inner workings, much less possess the knowledge required to engineer one of our own. I'm speaking, of course, of the human brain.

And despite what the naysayers who poke fun at our salivary management skills or suboptimal dentition may say, no single endeavor shows off its capabilities in grander fashion than a banjo player picking at a jam. Skeptical?

To illustrate, let's take a peek at what's taking place between your ears as you do something as "ordinary" as jam with your buddies.

The Coordinates of Cognition

While sharing features common to many other animals - including most notably our primate cousins - the human brain distinguishes itself in the intricate folds and crevices of its cerebral cortex and the trillions of connections contained within. This is where all the computational horsepower resides, and it is these parts that have allowed our species to write symphonies of breathtaking beauty, develop medicines to cure devastating disease, and design rocket ships that go to the moon.

In neuroanatomical terms, the cerebral cortex is divided into four major areas, or lobes: frontal, parietal, temporal and occipital. Generally speaking, the neural networks within each lobe are responsible for specific aspects of cognition.

Though these divisions are somewhat arbitrary, it is nonetheless instructive to consider the general function of each lobe in turn as we consider the neuroanatomy of banjo jamming.

Frontal Lobe

The frontal lobe is located, naturally, at the front of your brain, behind your eyes and forehead. It's a taskmaster, responsible for ensuring that all the other parts of the brain are keeping their attention on the job at hand. It helps them sort through the mountain of incoming sensory data and key in on the relevant bits.

The frontal lobe is what keeps you focused on the plucking of the bass player next to you instead of the car alarm blaring outside, for example.

The frontal lobe is also the initiator of movement. In order to execute a roll sequence in the right hand, the supplementary motor area in the left frontal lobe first must formulate a motor plan - a blueprint for the sequence of movements that must be performed.

Fortunately, the frontal lobe has a repository of stored motor plans from which it can draw, each the product of all those painstaking hours of fastidious practice. Once this plan is rendered, it is relayed to the appropriate targets in the adjacent primary motor cortex, which then transmits neural impulses into deeper parts of the brain, through the spinal cord and nerves and into the muscles of the forearms, the contractions of which generate movement of the fingers. The timing of these contractions is in turn precisely regulated by feedback circuits in the cerebellum - circuits whose influence can spell the difference between toe-tapping music and cringe-worthy noise.

A similar sequence of neural events is occurring within motor networks in the right frontal lobe; only in this case the motor plans are for chord shapes and left hand fretting movements. Of course, the movements of the left and right hands must be precisely synchronized, and this coordination is accomplished via a large mass of nerve fibers connecting the two halves of the brain, known as the corpus callosum. Without it, the two hands act independently, neither with any knowledge of what the other is doing.

If we happen to be picking and singing, the frontal lobe gets an even bigger workout. Language networks in the left frontal lobe connect motor programs for speech articulation with mental concepts (in this case things like willow trees and foggy mountains) housed in the temporal lobe.

As with right hand rolls, the final output is sent into primary motor cortex and relayed on to deeper parts of the brain, this time terminating in the muscles of the larynx. Corresponding networks in the right hemisphere also deliver their output into those muscles, serving to modulate the pitch and emotional content of the words we sing.

Temporal Lobe

At the bottom of the brain, just adjacent to your ear, sits the temporal lobe. As you might expect from its position, it is intimately involved with processing the sounds we hear.

To get here, sound is first transformed by the inner ear from vibrations of air against the eardrum into the firing of neurons, the language of the brain. Once that sonic information has been translated into neural code, networks in the temporal lobe - in an incredible feat of reverse engineering - parse it down into its component sources. Each sound source is then analyzed further to extract information like spatial location, pitch, and the type of instrument or voice from which it came.

These temporal lobe circuits also monitor the sound of what we're playing (or singing), so that we can determine if what we're actually playing sounds like what we *want* to play. And, if it doesn't, that information is relayed to the frontal lobe to make split second modifications to the outgoing motor programs controlling the fingers (or the voice).

Beyond its role in sound processing, the temporal lobe is also fundamental to memory formation. Contained within this region is a seahorse-shaped structure known as the hippocampus.

Scientists first learned of the hippocampus's function from H.M., a now-famous patient who, after having both his hippocampi (left and right) removed, was incapable of forming new memories.

It's our hippocampus that helps us remember the song we're playing along with its attendant melody, lyrics, and harmonic structure. Other nearby structures responsible for more immediate "working memory" keep track of exactly where we are in that song at any given moment so that we know what the heck to play next!

Occipital Lobe

Situated at the back of the brain is the occipital lobe, and the receipt and processing of visual information its domain.

The occipital lobe is where neural signals generated from light transduction across the retina terminate. Like the circuits in the temporal lobe that can turn vibrations of air into a detailed sonic map, networks in the occipital lobe are able to construct a complex visual scene from the electromagnetic waves of light that strike the back of the eyeball.

Once the scene is created, higher order occipital networks can then extract meaning from it. It is here, in combination with networks in the temporal lobe, where facial recognition algorithms tell you that the guitar player's scrunched up face means you're playing too loudly, or that the pale, sweaty faced mandolinist to your right would rather you skip him when it's his turn to solo. Feedback loops from visual to sensori-motor cortex also help guide your hand to the correct spot during those up the neck excursions with the left hand.

Parietal Lobe

Above the temporal and behind the frontal lobe sits the parietal lobe. The parietal lobe is where sensory information about the body itself is sent, including the fingers and hand.

For the banjo player, the type of body data we're most concerned with is the location of the various joints of the hands and arms. This joint position (or "proprioceptive") data is used to create a real-time spatial map of the position all of our body parts - data that those motor networks in the frontal lobe, in concert with feedback from those auditory circuits in temporal lobe, can use to modify the outgoing motor programs.

This is the feedback loop that allows us to adjust the angle of our wrist if our tone isn't clean, or rapidly switch from a D to and F shape chord if we've chosen the wrong one.

The parietal lobe is also where information from networks in all the other lobes - parietal, temporal, occipital - converges. It is in these regions of "multimodal association cortex" where all the disparate sensory data is bound together into a cohesive whole to create the unified, conscious experience of being banjo player taking part in a jam - an experience that will be delivered to the hippocampus for longer term storage so that you may revisit and dissect it long after it has ended.

Though this has only been a cursory overview of the cognitive neuroscience of jamming, I hope it at least impresses upon you the spectacular complexity of it all.

Virtually every domain of human cognition is brought online during jamming, each in parallel and at blazing speeds, utilizing almost every bit of the brain's immense computational power.

Indeed, in functional imaging studies where brain activity is visualized in real-time, no single human endeavor surpasses musical performance in terms of the amount of cerebral cortex involved. As someone who has spent their entire adult life studying the human brain, I consider musical performance - particularly those forms that contain an improvisational element - to be the ultimate expression of the brain's magnificence.

We may have written a computer program that can defeat even the greatest Grandmasters at chess or beat the all-time champions of Jeopardy, but we're not even close to engineering an artificial intelligence that could hold its own playing the 5-string at a jam.

So if you're new to jamming and perhaps feeling a bit intimidated about taking the plunge, or maybe frustrated that your first experience didn't go quite like you wanted it to, take heart, and cut yourself a little slack. In fact, we should all give thanks and marvel at the fact that such a wondrous thing is even possible.

Your Brain on Banjo: Lessons in Neuroplasticity

Using Your Ears

by Josh Turknett, MD

"I believe that anyone can learn to play the banjo by ear"
- Adam Hurt

To those who do it, playing by ear may seem as effortless as breathing. To those who don't, the prospect may seem as far off as the Andromeda Galaxy. To many folks, the ability to play by ear is seen as a natural gift. And if you weren't born with the gift, then you're stuck with learning by tab or notation.

This, of course, is nonsense.

Our Extraordinary Ears

Let's start with a brief overview of how our ear, or more specifically, our auditory system, accomplishes its primary task of transforming vibrations of air molecules into a rich and detailed sonic experience.

To begin with, all sound starts as a wave of air pressure set in motion by the vibration of a physical object. Once that vibrating air reaches our head, it bounces around the cartilaginous folds of the pinna (the part of the ear you can see), where it is concentrated and then funneled into the dark tunnel of the external ear.

Once they reach the end of that tunnel, the air molecules bounce up against the tiny tympanic membrane, also known as the "eardrum." Deflections of the eardrum are then transmitted and amplified by way of three tiny bones that make up the middle ear. The last of these bones, the stapes, transmits these vibrations to an even tinier membrane known as the "oval window."

On the other side of the oval window lies the cochlea, a snail-shaped chamber filled with fluid and lined with hair-like projections known as stereocilia. Vibrations of the oval window generate a fluid wave inside the cochlea, displacing the stereocilia and triggering the firing of a neuron - this is the moment when those vibrations of air are finally transformed into neural code.

That neural signal is then relayed through the base of the brain and into the auditory cortex, where it is parsed, distributed, and analyzed, the end result of which is your sonic experience of the world around you.

To help you fully appreciate this analytical feat, imagine yourself sitting in your living room listening to one of your favorite bluegrass albums. With virtually no conscious effort, you can easily distinguish the sound of the banjo, guitar, mandolin, and singer.

If your significant other speaks to you while the music is on, you have no difficulty identifying his or her voice, and you have no trouble distinguishing it as separate from the music. Meanwhile, all those extraneous environmental noises you're not particularly interested in at the moment are automatically filtered out as "background." If pressed, however, you could almost surely determine their source and location.

Yet, as you've just learned, all of this sonic information is transferred from the world to inside our cranium by the beating of air molecules against the tympanic membrane.

Incredibly, this exquisitely detailed, information-rich sonic landscape is created by the brain from nothing more than the deflections of a drum less than a centimeter in diameter.

The Process Demystified

Let's now contrast what our auditory system does during the course of its normal operation with what it must do when you play by the banjo (or any instrument) by ear. In a nutshell, here's the basic procedure for playing by ear:

Step 1: Hear a pitch in your head (i.e. in "mental space")

Step 2: Match it to a pitch that comes from your banjo (i.e. in "physical space")

Musical pitches are vibrations of air molecules that oscillate at *regular* intervals (or "frequencies"). Compared to the *irregular* vibrations that comprise most of our sonic environment - sounds that we decode with ease - musical pitches are much simpler. From the standpoint of complexity alone, then, **the cognitive procedure required to decode everyday sounds is more sophisticated than what's required to match pitches in physical and mental space**.

Now, guess what? If you sing, you've already demonstrated that you are capable of performing the basic cognitive procedure for playing by ear. You've demonstrated that you can match a pitch that exists in mental space to one in physical space.

The only difference in the case of singing is that the pitch is generated by the vibration of the vocal cords instead of a plucked banjo string.

I can hear some of you now exclaiming in hopeless resignation "I can't carry a tune to save my life!" If so, I have good news: the very fact that you know you can't carry a tune with your voice means that you have an ear capable of discriminating differences in pitches! After all, how else would you know you couldn't carry a tune if you were unable to determine that the note you sing doesn't always match the desired note in your head?

Your problem is not that you can't hear differences between pitches, it's that you haven't fully developed the ability to adjust your vocal cords so that they vibrate at the desired frequency. Not to worry, though, because when you play the banjo, this part of the process is taken care of for you (provided your banjo is in tune!).

So we've established that your ear and brain, in the course of normal operation, already accomplish auditory processing feats more advanced than playing music by ear. And we've established that a great many of you (both singers and those who know they can't sing!) have already demonstrated that you possess the tools required to play by ear.

Is there anyone out there who is truly incapable of playing by ear?

Congenital Amusia

Congenital amusia, commonly known as "pure tone deafness," is the inability to discriminate between musical pitches. Like color blind men whose brains are incapable of distinguishing different wavelengths of light (typically those in the red-green spectrum), those with congenital amusia cannot tell the difference between certain frequencies of sound waves.

These are the only folks who can make a legitimate claim to not being able to play by ear. But just how common is tone deafness, particularly out there in *Banjo Newsletter* land?

Congenital amusia runs in families, an observation that at least in part betrays a genetic origin (in fact, the very presence of such a genetic condition supports the idea that we are hard-wired to discriminate pitches). The uppermost estimate of the prevalence of congenital amusia in the general population is 4%, though some experts argue that the actual number is much lower than that.

Yet, even at 4%, the odds are heavily stacked in your favor. Moreover, most folks with congenital amusia don't find music particularly enjoyable, and so aren't likely to take up an instrument or subscribe to banjo-related periodicals.

Thus, the percentage of folks who are both learning to play banjo *and* tone deaf is likely much, much smaller than the estimated 4%.

If we put all of this together, **we find the odds that anyone reading this article right now suffers from congenital amusia and thus is incapable of playing by the banjo by ear are astronomically low**.

But, if in spite of the preceding discussion you *still* doubt your capacity to learn music by ear, I've created a short and simple banjo-centric test you can take to determine if you have what it takes. Just go to www.oldtimejam.com/eartest.html and follow the instructions.

Permission to Try

Clearly I agree completely with clawhammerist and banjo teacher extraordinaire Adam Hurt when he says that anyone can learn to play the banjo by ear. Contrary to what many may believe, playing by ear is not a natural gift. It is a *learned skill*.

Sadly, it's a skill many never even try to learn, thanks in no small part to the natural gift myth. But, rest assured, with rare exception it's a skill that anyone can develop through hard work and practice. In the next installment in this series, I'll talk about why that hard work and practice is worth the effort.

Your Brain on Banjo: Lessons in Neuroplasticity

Using Your Ears, Part 2

by Josh Turknett, MD

In the last installment of *Your Brain on Banjo*, we eradicated the myth that the ability to learn by ear is an inborn gift. Save those with true tone deafness, or congenital amusia, everyone possesses the requisite neurobiology to learn how to do it.

For some of you, the next question may be: why should I?

Before we go any further, let's get this out of the way: *this is not an anti-tablature article*. Tab (or notation) is a wonderful tool, with many uses that are beyond the scope of this discussion. Learning to play by ear doesn't mean you must swear off all written forms of music for the rest of your life - in fact, they can function as a helpful aid in the learning process.

That said, depending on tab exclusively might hamper you in ways you may not fully appreciate. The obvious limitations of a tab-only approach are that you'll remain dependent on written sources for learning new tunes, and on-the-fly improvisation is out.

But it can also obstruct your progress in ways that are a bit subtler. For those of you who've been tab dependent thus far, see if any of the following scenarios sound familiar:

You play a tune flawlessly at home, but it falls apart when you attempt it in a jam.

You'd like to add variations to the way you play a tune you've learned from tab, but find it nearly impossible to deviate from the arrangement you learned.

You find it really hard to play through tunes without the tab in front of you. Likewise, committing a tune to memory is a difficult, painstaking process.

What's to blame for these roadblocks? Let's take a look inside your noggin to find out.

Your Brain on Tab

Here's a rough synopsis of what happens in the brain when you learn a tune entirely from tab. First, light reflecting off the page of tablature enters your eye and strikes the retina, stimulating photoreceptors there that transduce the electromagnetic energy into nerve impulses.

Those impulses are then relayed on to visual cortex in the back of the brain where a rudimentary image is first decoded. Once this happens, the image data is then relayed to sophisticated association networks that extract meaning from it.

After the tab symbols are deciphered, the information is then sent forth to motor planning areas in the front of the brain where a movement plan is rendered. To execute that plan, nerve impulses are delivered to primary motor cortex, down through the base of your brain and spinal cord, into peripheral motor nerves that trigger the coordinated firing of the muscles that control your fingers.

If all goes well, the end result is an accurate sonic reproduction of the printed music. Through this process, the symbols on the page have been transformed into banjo music using your brain and body as the conduit. Pretty cool.

With practice, you can get quite good at this tab-reading procedure, eventually reaching a point where you can play through a tune as you read it.

This occurs thanks to the creation of tight tab-specific mappings between visual and motor cortex (i.e "see this, do this" connections).

Notice, however, that something is conspicuously absent from the aforementioned neural procedure for playing from tab: *the sound*. Though the outcome of this process was music from the banjo, our brain got us there without needing any sonic representation of the music whatsoever.

Our auditory cortex - the part of our brain that deals in sound - **played no part in the making of the music**. A bit odd, right?

With this in mind, those roadblocks mentioned earlier make more sense:

Why is it difficult to play a tab-learned tune in a jam? Well, it goes without saying that when playing music with others, listening is essential. Odds are we can't just plow through the tune exactly the way we play it at home with no regard for what the other musicians are doing.

On the contrary, to fit in successfully with others our brain must adjust the motor output to our hands *based on what we hear*. Yet, if we've excluded the hearing parts of our brain when we built our banjo playing neural networks, then we lack the needed neural machinery to make those adjustments.

This isn't some deficiency of musical ability; it's simply a natural neurobiological consequence of learning methodology.

And why is it so hard to memorize a tab-learned tune? Memorization without the benefit of auditory input is also a very tall order. To memorize a tune from tab alone, you basically have two options:

1) **Memorize the entire tab visually**. Save those with photographic memories, this is quite hard.

2) **Memorize the entire sequence of movements in the left and right hands**. While easier than the first option, this is still a challenging task. Not to mention it's no fun! Worse yet, these types of memories are both harder to form and more liable to degrade over time.

So if the neural networks built from a tab-only approach are limiting, what kind of networks would serve our needs better?

It's Child's Play, Really

The ability to communicate with our voices is so important to our species that Mother Nature has fine-tuned the learning process for it over millions of years. As a result, virtually every baby human is born a master at language acquisition.

Given the many parallels between language and music, childhood language acquisition provides us with an ideal model to emulate.

Consider then how a little girl learns to reproduce the sounds of her native tongue. To begin, she listens intently to every word uttered by the people around her, slowly building a repository of sounds that are specific to her language.

Then she begins to try to reproduce those sounds using the muscles that control the mouth, tongue, chest, and larynx (the vocal apparatus). These initial attempts at language are crude, but with practice become increasingly sophisticated. In just a few years, she's mastered the sounds of her language.

Through the aforementioned learning process, she has built an extensive library in her brain of correspondences between chunks of sound and movements of her vocal apparatus. These "sound-to-motor" mappings are so efficient that they are able to almost instantly translate her thoughts into speech. Furthermore, with these elements in place, learning how to say a new word is usually as simple as hearing it once.

Not surprisingly, almost all players who have achieved banjo mastery have followed a nearly identical path. It's a path that also begins with copious listening - this time to the sounds of the musical language he or she wishes to speak.

Through this intent listening, a repository of genre-specific (e.g. bluegrass, old-time, punk, etc.) sounds is constructed. Initial attempts to reproduce these sounds on the banjo are rudimentary and uncoordinated, but with practice become increasingly sophisticated and efficient. Eventually, through this learning process, an extensive library of correspondences between chunks of sound (a.k.a. "licks") and movements of the hands are formed in the brain.

In the master banjoist, these sound-to-motor mappings are so efficient that he or she can almost instantly translate imagined banjo sounds into movements of the hands. With these maps firmly established, learning how to play a new tune (and memorizing it) is as simple as learning how the melody goes.

Building Your First Sound-to-Motor Maps

The gift of neuroplasticity provides us the remarkable opportunity to customize our brains to serve our needs. Whether we end up building a brain that does so, however, depends entirely on how we practice.

So if your goal is to maximize your brain's banjo-picking potential, then building these sound-to-motor mappings in the brain is critical to doing so. To build them, though, *you must use your ears.*

If you've been an exclusive tab learner to this point, you may be unsure of how to start using your ears to build your own sound-to-motor maps. As with any skill you learn, the trick is to start simple and progress sequentially. Here are a few tips to get you going:

1. Always, always, always know how a tune is supposed to sound before you start learning it from tablature. Not only should you know the melody cold, but also knowing how the particular banjo arrangement should sound is ideal.

2. When learning a tune by tab, get the tab out of view as soon as possible. Get in the habit of using your ears, not your eyes, to tell you if you're playing a tune right.

3. Start trying to pick out simple, well-known melodies by ear (only the basic melody, don't add rolls initially).

4. Look up the chord progressions to some familiar songs. Then, practice strumming along to a recording, using your ear to tell you when you should change chords.

Remember, virtually every one of you has a brain capable of playing music by ear, even if the prospect of it seems daunting. With a little patience and persistence, however, you may one day find yourself wondering how it ever seemed so.

Want More Brain on Banjo?

If you enjoyed this series, then you'll be pleased to know that I continue to write on this subject over at clawhammerbanjo.net. So check in over there from time to time.

And if you're interested in applying these principles to your own banjo playing, check out my **Breakthrough Banjo Course**, a beginner to advanced methodology based entirely on the Brainjo Method of instruction.