What the Brain Tells us About Music: Amazing Facts and Astounding Implication Revealed

Newspaper headline writers, those obscure cubicle dwellers within the maelstrom of the pressroom, no longer write florid tag lines for stories. This practice, whose purpose was to draw a potential reader into the story, probably reached its peak around the turn of the century, that is the turn of the 19th to the 20th century.

"HORSE PERFORMS MATHEMATICS"

"Astounding Revelations — Equine Genius Taps Answers, Surpasses Eight Year Old Child in Ability to Answer Numerical Queries"

The titillating title tells us the main point — a "calculating" horse. We want to know more. The following tag line tells us we are dealing with a high level of mathematical intelligence, better than an eight year old! It also tells us how the horse gives answers, by tapping a hoof. Finally, we are told just how important it all is, indeed, how we should react — "Astounding Revelations".

Personally, I miss the enthusiastic over-the-top tag line, headline material generally being so dull nowadays. And TV news further chops away at the fun and information. The story above would be announced on the 6 o'clock news as "Horse Adds: News at Eleven!" As it turned out, when some "nasty" scientists got into the act, the horse, nick-named "Clever Hans", couldn't do arithmetic. It was picking up unconscious signals, like slight changes in tensing of facial muscles, from its owner (who was better than an eight year old at arithmetic). But that's beside the point. It is still a good headline and a great tag line.

My fondness for good tag lines surfaces at the head of this article on brain and music. Do I really mean that from studies on the brain and music we get "*Amazing Facts and Astounding Implications Revealed*". Well, that depends on what you consider "amazing" and "astounding". I think that findings outside of the public's imagination a few years ago, perhaps even today, are "amazing". The "astounding implications" part is something that readers can decide for themselves.

The findings and implications that I'm including in this essay are part of the larger picture that is emerging from music research. This is, **"Music is More Important Than We Think"**. This conclusion is really what has led me to a deep interest in music research and, in fact, is the common theme that binds all of the issues of *MRN*.

The present article is particularly timely because MENC, the Music Educators National Conference, the largest (by far) professional organization for music educators, has just

published a special issue of the *Music Educators Journal (MEJ)* on "Music and the Brain" (see *Matters of Opinion* in this issue of *MRN*). This itself would have been astounding not so long ago, for there has been a traditional divide between music education and behavioral neuroscience, the field that deals with brain and behavior.

As we consider some "amazing facts", let's not overlook Darwin's lament near the end of his creative career. He believes that his intellect would have benefited from a greater involvement in music. Whatever the effects might have been on him, Darwin, the supreme scientific genius of biology and human heritage, believed music to be important for brain function. And it is, but in many ways that neither Darwin nor most people could imagine.

We Don't Know What We Know — The Need for the Brain to Tell Us What We Know

To begin with, why should we take the title of this essay seriously? Why should we need the brain to tell us anything about music? Music is music! We can observe music behavior in others and reflect on our own experiences. If we have a question about music, shouldn't we be able to arrive at an answer just by observing others and thinking about what we know? For example, if we want to know how many people are "musical", why can't we just count the number of people who learn to play an instrument? If we want to know why a professional violinist is starting to have trouble fingering, a colleague or master teacher just needs to look at his technique and correct it.

The main reasons why observing others and thinking about our own experiences are inadequate is that we really don't know what we know. To be more precise, we know a great deal that we have no awareness of knowing. Much of our experience is not really directly accessible to our own thoughts and reflections. In short, the brain is set up to use many, perhaps most, of our experiences without "allowing" them to gain access to our consciousness. This mass of information is stored within us, yet is invisible to our own awareness.

To cite only one example, every one of the thousands of muscles throughout our bodies continually sends information to our brains that gives the exact amount of stretch or contraction on it at any one moment. Try to make all of this conscious now; we can't. We can sense when a muscle is injured or over-stressed; the pain information can reach awareness but not the other information.

As for music, our auditory system is able to organize streams of sound into the specific perceptions that we experience consciously. So we can be aware of the trumpet tooting, the drum beating, or any of an uncountable number of musical sounds. But, although our perceptions are experienced so easily and immediately to us, they are possible only because of the previous unconscious workings of the auditory system. A prime example is that the auditory system "automatically" takes the cacophony of stimuli reaching our ears and groups it into meaningful chunks that we experience as coherent music. Dr. Diana Deutsch of the University of California, San Diego, has been a major contributor to

psychological studies of this process. We quote one example. “When a sequence of tones is presented at a rapid tempo, and the tones are drawn from two different pitch ranges, the listener perceives two melodic lines in parallel, one corresponding to the higher tones and the other to the lower ones.” That is, the brain groups tones that are closer in pitch, and so we perceive e.g., a melody in the treble and another melody (which we may call harmony) in the bass. Automatic, unconscious grouping of tones also takes place for other musical building blocks, e.g., tempo, timbre. The brain also groups sounds, tending to fuse them together, according to place in space. This is the basis for seating the same instruments together in an orchestra. Moreover, “expectation” is a powerful grouping force; if a note seems to complete a musical phrase, it is “assigned” to that phrase, even when it may not be closest in pitch, etc.

So we know from psychological studies that much of our knowledge in music is unconscious or “implicit”. What can the brain tell us? Two sorts of things.

First, it can tell us how it all works… what goes on in the brain to make both the conscious and the unconscious processes in music, whether listening, composing or performing. That’s simply because the brain is the cause of both behavior and of our conscious awareness, thoughts, perceptions and the like. Also, when things go wrong, the brain can tell us what has gone wrong and potentially how to fix it. As we will see, the violinist with fingering problems falls into this class.

Second, but probably more important, *the brain can tell us what our actual musical capabilities are, even those which may never surface either in behavior or in consciousness.* Why is this important? Because to understand the importance and potential of music in human life, we have to first understand human musical capabilities. The popular belief on this subject is that a fraction of people are “musical”, are born with “talent”; the rest are essentially musical clods, destined to fail if they try to learn a musical instrument.

You Don’t Have To Be A Musician To Have A Musical Brain: All Brains Have Complex, Unconscious Musical Processes

If you ask a randomly selected person on the street if he or she is “musical”, you will probably get a negative answer, unless she or he is a singer, dancer or plays a musical instrument. In many cases, even those who play an instrument are likely to tell you that they are not really “musical” but work at playing anyway.

Now for an “amazing fact” with “astounding implications”. *Nonmusicians are musical*. In a recent study, Stefan Koelsch and co-workers at the Max Planck Institute of Cognitive Neuroscience and the University of Leipzig, Germany, recorded the brain’s electrical response to various chords. They studied people who had absolutely no musical education or training. Subjects heard sequences of chords which infrequently contained a chord that did not fit their sound expectations. So the first point is that people with no musical training nonetheless automatically and unconsciously set-up certain expectations of which chords “fit” in a sequence and which don’t fit. This unconscious expectancy,

which they could not consciously talk about, was established by playing a set of chords that were appropriate for a certain key. Since any individual chord always belongs to several keys, the subjects were unconsciously "extracting" a "tonal center" (i.e., the key of the chord sequence) by comparing musical relations among the several chords. When a sequence of chords all belonged to the same key, the brains showed no special response. But when one of the chords did not fit the key that was implied (and unconsciously abstracted by the non-musicians), then it produced a particular brain potential, which essentially was equal to "this chord doesn't fit the key". This occurred although the subjects had no musical training, did not know about keys, about the belongingness of chords to keys, etc.

This is *amazing* because the brain tells us that it is calculating complex musical relationships, setting up musical expectations, and detecting violations of these expectations, even if the brain's "owner" doesn't "know" it, has done nothing consciously, has put forth no effort, *and in fact isn't aware that this is going on inside his or her head*. Why do I think that these implications are *astounding*? Well, the findings show that non-musicians are highly musical, implying that the normal human brain is a musical brain. How else can one explain these complex, unconscious musical computations and expectations? So, everyone has the brain equipment to "do" music. Further, the facts strongly suggest that music is part of normal human nature. The authors consider it possible that this unconscious ability to automatically analyze music and set up expectancies, which are based on rules of Western tonal music, could be biological, i.e., that the basic elements of Western tonal music might be built into the human brain. This may seem ethnocentric but it should be testable scientifically. An alternative is that exposure to Western tonal music early in life is responsible for this remarkable capability. A next step could be to determine the age after birth when the brain starts to perform its amazing and astounding unconscious musical work.

Playing a Musical Instrument Reshapes Your Brain

Moving from the "listening" side of the brain to its "performance" machinery, we come upon the amazing fact that playing a musical instrument reshapes the brain. This doesn't mean it actually changes the overall shape of the brain but rather that coordinated use of the fingers can alter the brain's ability to distinguish touch input from different fingers on the same hand. To appreciate this fact, and its astounding implications, we need to understand how the brain normally processes touch (tactile) input from the skin. Briefly, different parts of the body surface send information to different parts of the somatosensory system, which is concerned with touch. Adjacent places on the skin project their information to adjacent places in the brain, resulting in a "map" of the body inside the brain. One can find a "map" of the hand and its individual digits, with neighboring brain cells receiving information from neighboring fingers.

This organization means that when using adjacent fingers in a highly coordinated or simultaneous fashion, as in playing the guitar, clarinet, violin or piano, adjacent brain cells are receiving simultaneous stimulation and are activated together. Brains apparently have a rule about togetherness, which is something like "Cells that are active together

become more closely connected". An amazing fact is that this can lead to more cells being "recruited" to the task, so that the brain area that processes information from a violinist's left hand becomes larger.

However, there is a flip side to this situation. In some cases, estimated to be about 15%, long term, repetitive practice can lead to the loss of control of individual finger movements, to a greater or lesser degree. This condition, termed "focal hand dystonia" has been studied in the brains of musicians who play the guitar, piano, oboe, flute and clarinet and suffer from this condition. The amazing fact here, unwelcome though it may be, is that the brain no longer maintains separate fingers in the map of the affected hand. Rather, cells that once responded mainly to input from one finger now respond equally to input from adjacent fingers, those that were used together over extended practice sessions. In this case, playing music is remodeling the brain in a negative way. Fortunately, therapies based on the brain findings are being developed.

One "astounding" implication is that a person can "grow", i.e., increase brain regions by musical practice, shaping your own brain according to what you do. Another is that we can now understand why "Practice Makes Perfect". Practice makes it easier for involved brain cells to work more efficiently together. That is, practice helps make "perfect" because it links relevant brain cells together. Another implication is that perhaps too much practice is hazardous to the brain. Thus, simply doing more practice can be beneficial up to a point, but thereafter it might need to be assessed carefully for any signs of dystonia. Alternatively, therapeutic hand exercises combined with instrumental practice might make an individual "immune" to dystonia. This remains to be determined.

Concluding Comments

What the brain is beginning to tell us about music may not seem as truly amazing as a horse that performs mathematical reasoning. However, what it tells us has the compensation of being true.

Views and decisions about music rest on several basic beliefs. Among these are that only a minority of people are "musical" and that for those who are so endowed, the more practice, the better. As music research moves forward, we learn more about ourselves and about the place of music in human life. While brain research in music is still in its formative stages, it is already clear that the brain can tell us many things that could otherwise not be known. When long-held beliefs are examined by the laser beam of science, we find that we can see music in a new light. The brain tells us that we are all musical, that our nature is to unconsciously make musical sense of sound. The brain tells us that the very act of performing music changes our brains, and therefore changes in a deeper sense the individuals we are. These *are* amazing facts with astounding implications and yet only a beginning. The brain has much to teach us. The marriage of music with brain research and modern technologies speaks loudly. We need only to listen.

— N. M. Weinberger

http://www.musica.uci.edu/mrn/V7I3F00.html#tells