

# **Science of Music and the Brain | How does music work, and how does it affect us?**

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Based on the work of Professor Daniel J. Levitin, Ph.D.

## **I-Sound and its physical properties: What is sound?**

### **II-Basic musical notions: Definitions**

### **III-The musical element:**

#### **A- Sound waves to musical notes**

#### **B-History: Math and Music**

#### **C-Interpretation**

### **IV- Neurological Approach**

#### **A-The Brain: Intro**

#### **B-Music in the Brain:**

### **V-Feeling of Music**

#### **A-Physiology**

#### **B-Musical Expectation**

#### **C-Music and Culture**

#### **D-Musican / Medecine / Learning**

### **VI-Universality of Music**

#### **B-Evolution and Music**

For the longest time, science and art were seen as two separate notions, completely opposed one another. The misconception that art and music reside in the right hemisphere of the brain whereas science and language lie in the left has been thrown around thoughtlessly throughout the centuries. There has been the constant need of separating art and science when ironically, these notions are fundamentally linked. Music as a science seems to be a recent interest, however, this whole area of interest can be traced back to as early as Pythagoras' era (570-495 BC).

Music is a language that everyone speaks, although music can be specific to a culture, it is still universally recognized. Art (and music) is the only universal way of conveying emotion. Music can manipulate one into feeling certain emotions, for example, a sad song in a movie sets the mood for the scene before the scene actually takes place.

Music is in fact very similar to science (because it is a science). The thought process involved in science and art is almost identical. The first task of an artist or a scientist consists in establishing an exploratory step also known as "brainstorming", followed by a series of experiments (through trial and error). Through experimentation the artist/scientist seeks refinement of the primary idea. The main goal of an artist or a scientist is to search for a single yet universal truth. However this one truth is not obtainable, it is completely relative and depends on the point of view.

To fully understand the impact of music, one must study music in all its scientific forms; From the physical properties of music, through its mathematical complexity and from its neurological impact through chemical exchanges, all in taking into account the notion of culture's impact on music through evolution.

## **I-Sound and its physical properties: What is sound?**

To talk about music, it seems important to talk about sound first. A sound is simply a traveling wave having a certain frequency (reciprocal of the period of the wave). After a perturbation, the atoms in the air vibrate, this causes a sound wave. However this sound wave is only relevant when interpreted by the ear. (We shall take the human as a reference). To explain; if a bird chirps, the sound waves produced will find their way to the ear of the human. The ear doesn't "hear" the sound waves. It simply gathers the sound waves, and amplifies them until they reach the Tympanic Membrane (ear drum), eventually reaching tiny hair cells in the inner ear which are imbedded in a fluid. These hairs are mechanoreceptors (they respond to stimuli). When stimulated, these receptors release a neurotransmitter (chemical). With enough stimuli the hairs on the cells bend enough to create a nerve impulse which is then analyzed by the brain. The cells are organized in such a fashion that at one end there are the hairs that can be stimulated by the high pitch sounds and on the other end, there are the hairs that can be stimulated by the low pitch sounds. Of course there is the entire range of pitches in between.

Therefore there is no real "sound" just sound waves at certain frequencies (20-20,000 Hz is the human threshold ) which are turned into nervous signals. Through this we can safely address the fundamental question posed by George Berkeley "If a tree falls in a forest and no one is around to hear it, does it make a sound?". The tree does not make sound just vibrations in the air which the brain "chooses" to interpret as sound. Just as the bird chirps makes no sound. This validates John Locke's distinction between primary and secondary qualities. John Locke established that a primary quality was the irrefutable properties of an object, such as solidity, extension, motion, number and figure. Whereas a secondary property was subjective and exists only due to sensations from the observer, such as: colour, taste, smell, and sound. Sound is nothing but a secondary quality, and it is completely subjective.

However, there has to be something capable of interpreting the vibrations and sending signals to the brain.

Problem:

This being said, now we are presented with a new problem. If sound is simply explained by physics, and is nothing more than a conversion of sound wave to nerve impulse, how can music have such a profound effect on us?

Let's say the sound waves are music (see below for explanation from sound wave to musical element). What makes this music (sound wave) which is converted into a nerve signal different from a simple noise (see definition for noise). How can the sound of music make someone feel emotions when it is simply layers of sound waves whereas a simple noise\* provokes no emotional response but is also multiple layers of sound waves? How can somebody find the sound of a jackhammer irritating but the sound of a certain "music" appealing?

To even begin to answer this question, it is necessary to explain what certain elements of music are.

## II-Basic musical notions: Definitions

To address this issue it is imperative that we explain some basic yet essential notions encountered in music.

--> When a pianist for example, hits one key on the piano, or a guitarist plucks one string on the guitar, it produces something that is known in science and music as a "**tone**" but most of us know it as a "**note**".

(In western music the notes go from A to G **or**, do, re, mi, fa, sol, la, si, do)

First off it is important to note (no pun intended) that a "tone" has a certain frequency and so the "**pitch**" is related to the frequency of a "tone" in question, but is also related to its position on the musical scale. A "pitch" is essential to creating a melody. For example if

we take a song with a constant rhythm (defined below) but a varying pitch we can obtain a melody. ex: "Mary Had a Little Lamb". In this song, the the rhythm is constant throughout the syllables however it is only the pitch that changes.

--> The "**rhythm**" is equally important in a melody. The "rhythm" is basically the duration of a series of pitches (or one pitch). The series of pitches are separated into units sometimes separated by silences. Melodies can be built using one pitch and varying rhythms for example the first four notes in The Beatles' song "Come Together". They maintain the same pitch but the varying rhythm is what makes the melody unique.

--> It is then important to define the "**timbre**". Although the exact definition of timbre has been argued about, overall, it is what is unique for every instrument. This is what sounds different when two different instruments are playing the same pitch. For example: it is because of the "timbre" that a "C" (do) played by a violin and a C played by a trumpet (at the same octave) sound different. This difference is produced by an overlapping of other frequencies created by the instrument.

--> We also talk about :

- "**amplitude**" of a tone, (basically the loudness)

- the "**tempo**" of a piece (overall speed of the piece)

- the "**contour**", (the shape of melody, if it goes up or down the octave, and how it varies)

- and finally, the "**reverberation**" which is simply the perception of distance from the sound in relation to the setting (difference between singing in a tiny room and singing in a large concert hall)

These rudimentary elements in music combine together to give way to more complex concepts in music, for example : meter, key, melody and harmony.

-The "**meter**" is created by the loudness and the rhythm. It is the brain that creates the meter by processing these concepts. The meter is simply the way the tones are grouped together in time.

-The "**key**" is a very interesting notion in music. It is completely psychological. It is a series of tones where a certain one dominates and the difference between a tone and the next is a certain ratio. It functions entirely on the knowledge of a certain musical style. For example : blues is often associated with the key of E (mi) that means that the other two notes in a blues song key of E will be the A (la) and B (si). If we played blues in the key of F (fa) we would have the other notes in the song be A# (la diesis) and C(do), and if we played in the key of F# (fa diesis), the other notes in the song would be the B (si) and C# (do diesis). Different musical styles have different ratios and so they can be played in any key as long as the ratio of the certain style is maintained.

-The "**melody**" is basically the theme of the certain piece of music. It is what is most memorable in the song when one tries to remember it. The succession of pitches and the rhythm stand out. But a melody can switch depending on the musical style.

### **III-The musical element:**

#### A- Sound waves to musical notes

As mentioned above, if all "sound" is nothing more than a wave, a simple disturbance through space and time, than what makes a note? What makes a musical element and why is it different from simple "noise"? (In acoustics, a noise is an unwanted and meaningless "sound") . How can one classify the sound from a piano as something soothing and call it music, and on the other hand consider the sound from a jackhammer as being annoying and nothing more than a "noise"?

Also the main difference between a musical sound and a noise is the sound wave. The sound wave produced by an instrument is a wave with a pattern and a cyclical

movement, which is well organized whereas the sound waves created by a clap spreads in a chaotic way with no pattern and no order.

The basic relation between the pitches can be explained by the frequencies. As mentioned earlier sound is nothing but waves at certain frequencies. And it just so happens that musical pitches have particular frequencies. This is where the famed Pythagoras comes in.

### B-History: Math and Music

\_\_\_\_\_ One day, Pythagoras created a monochord (one-stringed instrument). Let's say he tuned the monochord to D (re). Pythagoras realized that when he pressed on the exact middle of the string, and plucked both sides, he obtained D on both sides but one octave higher. Pythagoras experimented with different ratios  $1/2$ ,  $3/2$ ,  $4/3$ ....etc...

He noted that the simple ratios sounded better. Pythagoras was able to prove that strings of equal tension but proportionate lengths emit waves of proportionate frequency, (basically pitches of proportional frequency). In doing so he was able to recreate the musical scale with different ratios of string length.

Because of Pythagoras' discovery, later people were able to elaborate that if a pitch of A (la) had a frequency of 440Hz, then the pitch of a wave of 880Hz would also be A, and so would the pitch of a wave of 1760Hz (and so would the pitch of a wave of 220Hz, 110, 55Hz, and 27.5Hz). The doubling of each pitch is simply going to a higher octave, and the products of the frequencies with the ratios that Pythagoras obtained led to the discoveries of the frequencies of different pitches.

For example: the first ratio after the 1:2 that Pythagoras used was the 2:3 ratio. So in this example we use the 2:3 ratio.  $(2/3) \times 440 = 293,3\text{Hz}$ . With modern technology we have identified a wave with a frequency of 293,3Hz. This wave represents the pitch of D (re). Therefore, Pythagoras was able to establish the octave. On the scale, D is at an interval of 5 pitches from A so Pythagoras established the following ratios for intervals:

1:1 = Unison

1:2 = Octave

2:3 = Fifth

3:4 = Fourth

4:5 = Major Third

(See grid for list of pitch frequencies)

<http://www.phy.mtu.edu/~suits/notefreqs.html>

### C-Interpretation

Although it is clear that the brain is what interprets music, it is important to realize that math is a determining factor in music. To explain this we have to go back to the definition of "**intervals**".

The "interval" in music is the distance between two notes. In the octave, the notes are divided in 12 equal spaces (logarithmically equal).

for example:

A-1->A#-2->B-3->C-4->C#-5->D-6->D#-7->E-8->F-9->F#-10->G-11->G#-12->A  
\_\_\_\_(Bb)\_\_\_\_\_ (Db)\_\_\_\_\_ (Eb)\_\_\_\_\_ (Gb)\_\_\_\_\_ (Ab)\*\*\*\*\*

\*\*\*\*\*there is one step between each note. Consequently the octave presents 12 half-steps. The half-step is the difference between a sharp (#) or flat (b) note and a major note. Therefore, the "sharp" of one note is the "flat" of the one after it.

Ex: C# <=>Db or G# <=> Ab.....etc...

(however, B and E are exceptions. The interval between B and C is a half-step, same thing for et interval between E and F).

So there are 12 "equal" intervals in the octave. The intervals are what make the melody of a song. More so than the pitch. It is not the exact pitch that creates the melody, but the interval between the pitches. The frequency of the pitch is arbitrary. The A pitch

could be set at different frequencies, like 400 or 480. It can vary but we can still obtain the same music. What defines music is not the pitch but rather the "pitch relations". The distance from two frequencies (of pitches) is what matters. In looking at the grid above, we notice that each note has a frequency which is around 6% more elevated than the frequency of the note before it.

Example :

A--> 440

$$440 + 440 \times (6/100) = 440 + 0.06 \times 440 = 466,4$$

(now look at the value of the frequency of A# on the grid)

A#-->466,2Hz

So we have determined that it is the distance between two tones that makes up a melody, and not the exactitude of the frequency of the pitch. Now it is interesting to think about how the brain favors the mathematical simplicity of the ratios found by Pythagoras, and how the brain seeks symmetry in its building of melody and music. Numerous musicians and artists have tried to replicate geometrical exactitude as something that will appeal to the brain and to the audience. This is one of the many neurological mysteries scientists have come across. Why is symmetry favored by the brain. Why do the simpler fractions "sound" better than the complex? Although this will not be answered in this paper, we are however brought to our next part which focusses on the brain itself.

## **IV- Neurological Approach**

So it has been explained that music initially is a series of sound waves that are interpreted by the ear and are the building blocks for any sound. Now music is a sound, this sound has a certain frequency which can sound "good" or not. But music, like any art form is not universal. Although there is a universal understanding of beauty, and a universal recognition of what is beautiful, it is obvious that every individual likes different

arts. It is also obvious that certain pieces of art (music included) invoke different emotions, provoke different reactions, and evoke different expectations. All this is unquestionably related to the brain.

The study of music is generally done by cognitive scientists that focus on the mind whereas neuroscientists (obviously) focus on the brain when studying music. The study of the brain in music seems the most logical. By studying all the physical (biological and chemical) changes in the brain we can understand how profoundly music affects us. Cognitive scientist who focus on the mind are limited in their research because they fail to take into account the actual physical changes in the body. This is where neuroscientists have the upper hand.

#### A-The Brain: Intro

The brain is the organ located in the skull, it is made up of cells, tissue and neurochemicals. The common misconception related to the brain is that it is usually compared to a computer. Comparing the human brain to a computer would completely undermine the value of the brain. The human brain is infinitely more complex than any computer or machine. The reason for this is the brain's capacity to process information in parallel whereas the computer does things one at a time. Although you don't realize this for the computer because it performs single tasks very quickly. The brain works in parallel, and the speed with which it processes information is exponentially quicker than the computer. The reason why the brain functions in this "parallel way" is all because of the cells that constitute the brain: the neurons.

The brain's complexity and efficiency is related to the number of neurons as well as the capabilities of a single neuron. First off, the average human brain consists of over a hundred billion ( $10^{11}$ ) neurons. This huge number is part of why the brain is so quick and efficient in information processing. However, it is most important to note the capabilities of the neurons individually. Neurons connect together to make circuits. The connection between two neurons is called a **synapse**. Experience, or learning does have

an impact on those neurons. More synapses are created through experience and learning. Learning an instrument for example creates synapses and establishes new neuron-networks in the brain. Each of the hundred billion neurons can have as many as 10 000 synaptic connections to other neurons. The average amount of synaptic connections in the brain is around 7000. One can imagine the amount of synapses in total in the brain. An estimate of the total number of synapses in the brain is around the hundreds of trillions ( $10^{14}$ ). It is important to note that not all neurons connect to 10 000 other neurons. They just have to capacity to do so. A neuron can connect to 10 000 other ones or can connect to just one other neuron. This makes the complexity of the brain even more flagrant. With the increasing number of neurons, the number of possible synapses increases exponentially. This is the number of "**possibilities**" not the number of total synapses. For example:

-Two neurons can be connected or they can not. Therefore with two neurons, there are two possibilities.

- Now take three neurons: a, b, and c

(i) a, b, c can be all separate

(ii) a, b, c can be all connected to each other

(iii) a and b can be together and c separate

(iv) a and c can be together and b separate

(v) b and c can be together and a separate

(vi) a and b and a and c can be together but not b and c

(vii) b and a and b and c can be together but not a and c

(viii) c and a and c and b can be together but not a and b

With this example we can see that with only 3 neurons, there can be 8 different possibilities of connections. With this reasoning, scientists came up with a formula to demonstrate the number of possibilities that a certain amount of neurons could be linked together. With  $n$  neurons, there are  $2^{(n(n-1)/2)}$  possibilities of connection.

-for 5 neurons we get 1024 possibilities.

-for 6 neurons we get 32 768 possibilities.

-for 10 neurons we get 35 184 372 088 832 possibilities (over 35 trillion)

So for ten neurons there are over 35 trillion possibilities of connectivity. Now take into consideration that the human brain has on average 100 billion neurons. The amount of possibilities is  $2^{(10^{11}(10^{11}-1)/2)}$ . (unfortunately, the Texas Instruments 89 can not calculate such a huge number due to overflow but the number of digits would probably exceed this whole page). To give you an idea, it is 2 to the power of (4999999999950000000000).

This shows the immense and unimaginable diversity of the human brain. This however raises a major issue.

With such a huge diversity in the human brain, why do humans feel the way they do towards music? Although music is interpreted differently in every human, there is a universality in it. To study this we shall focus on music in the brain.

#### B-Music in the Brain:

When the vast majority of people consider music and the brain they believe that in the brain there is a center for music, just as there is a center for visual arts, a center for math, a center for language etc... This is a common misconception, and it is completely false.

The fact of the matter is that there are many "music centers" in the brain. First, it is important to describe the path of music in the brain. Music (actually sound in general)

As explained earlier, when the sound is created it is amplified in the outer ear and makes it's way to the middle ear where it meets the ear drum (or tympanic membrane). The ear drum causes the movement of the malleus, which moves the incus which moves the stapes (three smallest bones in the human body). The movement of the stapes causes movement in the fluid inside the cochlea ( portion of inner ear). The fluid contains hair cells arranged in order of highest to lowest pitch. The stimulation of these hairs by certain pitches causes a signal which goes through the inferior colliculus and then is sent to the

auditory cortex of the brain through the brain stem. The auditory cortex of the brain is also organized by pitch order in a sort of piano-like organization.

Once in the auditory cortex, many different areas of the brain are activated when listening to music. For example a part of the brain will react particularly for pitch, another for tempo, another for loudness and another for timbre. When listening to music, all these areas are activated in the brain through parallel networking. The pitch will be analyzed in the auditory cortex while the tempo will be analyzed in the frontal lobes where motor functions are controlled, and the timbre will be analyzed by the hippocampus, the cerebellum, or the striatum where memory and procedural memory is analyzed...etc. This thwarts the common misconception of the single music center in the brain. All these different areas work together in a parallel method and all the analysis is performed in the 30 000th of a second. This is much quicker than any computer.

The following image represents the brain structure involved in music.

<http://www.brainmusic.org/AuditoryNeuroscienceFolder/Fig1.gif>

We can see in this document that every part of the brain is used during the process of listening, making or accompanying music.

It is clear that music has an impact on the brain like any other action, experience or external factor. But the initial problem persists: What makes us feel music? Why does it affect us in such a way?

## **V-Feeling of Music**

Why do we feel the music the way we do? Why is it that we recognize scary music as being scary? What makes us like a particular type of music or a particular song? Why do happy songs cheer us up whereas we tend to listen to sad songs when we feel sad? What does music bring to us?

This is the major bullet-point of this article. The feeling of music is such a vast notion, that it is nearly impossible to explain it all. Above that, cognitive and neurological research on this topic has only developed in the last 10 to 15 years, and there are still many mysteries to music.

### A-Physiology

You don't only hear music. You can actually feel music. It is obvious that you can feel music because it is a sound wave therefore a vibration in the air, but you can also feel music in your body. This can be seen when someone unconsciously taps to the tempo of a song that is playing. This can be seen when a song is particularly haunting or has such an impact that it makes your hair stand on end. This can be seen when one gets shivers from a powerful song. This can be seen when someone cries at an opera but it can also be seen when someone can not help but smile while listening to a song. These unconscious reactions to certain music leads us to think that music, as irrational as it sounds, can physically as well as emotionally touch someone. It sounds irrational to think of it like that. But if you think about it, stimuli like touching a flame provokes a physical response. So why wouldn't music provoke a physical response? The skin response when listening to music acts just like the motor response of removing the hand from the flame. The body is prepared for music.

It is interesting to speculate on what makes music do these things, or what elements in music engage physical response. Scientists also speculated on this topic. Thus, Professor Daniel Levitin Ph.D. led an experiment where an individual listened to music and the oxygen delivered to his neurons was recorded. The experiment revealed that the happy music stimulated the nucleus accumbens, the hypothalamus, and the ventral tegmental regions of the brain. All three responsible for the delivery of dopamine in the system. Dopamine is a neuro chemical which serves as a neurotransmitter. Dopamine is associated with the reward system of the brain, and the feelings of pleasure.

Dopamine is usually released with food, sex, and drugs. Levitin's results confirm that music has a physical (mostly biological) impact on us.

Listening to a sad song when feeling sad is purely psychological. Nowadays people listen to music mostly when going somewhere, so during transit. Listening to music closes one in a bubble and separates the person from the outside world. Therefore, listening to a sad song when sad is directly related to the fact that you associate and relate yourself to the music and are no longer alone. However this probably has a neurochemical consequence. The fact that you listen to a sad but beautiful song must feel rewarding and release dopamine and endorphins as well. Neurochemistry is a complex science with an unimaginable amount of outcomes to a particular situation as well as a flagrant speculative reasoning. Music probably releases many chemicals like **dopamine** and **endorphins** for pleasure, **epinephrin (adrenaline)** for an exciting song, or **acetylcholine** for memory and sensory perception. It is very difficult to pinpoint exactly what chemicals are released when and for what reasons due to the complexity and multi-purpose of different brain regions.

For example, the frontal lobe is related to motor movement and memory as well. Does that mean that if there is a massive oxygen flow to the frontal lobes both epinephrin and acetylcholine will be delivered? Or is it one or the other?

What we do know is that music excites the brain and the body, and a major factor in that is musical expectation.

### B-Musical Expectation

\_\_\_\_\_What makes music interesting, and therefore rewarding and ultimately provoke a reaction it expectations. What one expects is going to happen in a musical piece before it occurs. When a pattern is repeated, the listener starts thinking of the pattern and assuming what will happen next. This is the core of music. With expectation, the listener starts feeling music in a way that a musician would. This is illustrated by Bobby McFerrin in the conference "Notes & Neurons" at the *World Science Festival*.

(fourth video, 1:50 in)

<http://www.worldsciencefestival.com/video/notes-neurons-full>

Here, McFerrin is able to create a spatial metaphor of music and uses the audience's expectations to build up a song.

One can assume that when the expectation is fulfilled in a song, the listener feels a sense of reward and thus dopamine is released and ultimately producing a feeling from the listener. However fulfillment of expectation is not the only device used in music. We see a lot of "broken rules" in music, with musicians purposely creating a pattern and breaking it in order to violate the listener's expectations. In doing so, the listener feels a frustrated curiosity.

An example of a broken expectation is : **syncopation**

Syncopation is an unexpected variety in beat, usually in relation to the strong and weak beats in stressed patterns.

With syncopations, the rhythm of the music is locked in the cerebellum, and the frontal lobe tries to predict the change in rhythm.

Expectation is what makes music such an interesting thing. It keeps the listener thinking. The brain is constantly analyzing changes in patterns which is a beneficial exercise for the human brain. However, expectations in music are not the same for everyone. In fact music in general varies for different groups of people. Music depends enormously and almost entirely on culture.

### C-Music and Culture

Different cultures present many variations of what we see everywhere. It is the same for music. It changes a lot depending on the culture. An example of this is the western notion that Major chords seem joyful whereas Minor chords seem sad. In eastern music (notably Arabic music), the minor chord is used to express many joyful feelings. This is probably due to the intonation of the culture's language. Language plays an

extraordinary part in music and culture. There have been tests where two composers: a French and English composer, had their pieces sampled by a listener and the listener was able to guess simply by the music which composition was written by a French composer, and which one was written by an English one. This is also due to intonation and the use of vowels in language that are substituted by notes in music. Music from a culture with a specific language is based on that culture's language and follows the timing of spoken language and the rhythm of it.

A difference in culture is not only the tone but also the use of scales. Although the octave is used by every culture in music, some cultures use different notes more often and are make use of them in improvisation and expectation much more. An example of this is in indian music where a chord used very often is the D flat. Neurologists have conducted an experiment where a western singer, listened to a piece of indian music and had to improvise on that piece. At first the singer improvised with no use of the D flat, however, on her second try, she started using the D flat. She had succumb to a sort of acculturation.

Indian music sounds dissonant to some western listeners, however the Indian music, much like the western music is set to the universal intervals. What indian music does is that it masters the intervals and then focusses on the nuance of the music which makes it sound dissonant.

Culture in music is related to neurons as well. In learning this new culture's ways, links between neurons have been established and this is an example of a neurological event caused by a cultural experience. This illustrates the impact of the exterior world with the brain. It shows how music can directly affect the human brain.

D-Muscian / Medecine / Learning

With music so closely related to the brain, it seems rational to assume that music offers benefits to the brain and therefore to the human body. Notably in the fields of medicine and learning.

Listening to music and playing music are two completely different things. If listening to music creates oxygen to the brain and stimulates neurons then playing music must offer many benefits as well. Extensive studying of the brain in musicians and non-musicians have shown that music when learnt offers a wide variety of benefits.

Studies under Professor Robert Zatorre have shown that the brain of musicians have undergone physical changes. Some of them being :

- thickening of the outer areas of the cortex (close to auditory cortex)
- as well as thickening of the frontal cortex
- and an enlarged corpus callosum

The thickening of the outer cortex leads to better hearing and motor skills, whereas the thickening of the frontal cortex leads to improved planning, language and high order thinking. The enlarged corpus callosum has a particular consequence. The corpus callosum is located between both sides of the brain, and it's thickening leads to a more efficient and dual coordination (of hands and fingers mostly).

Another experiment was made on a person who had no musical experience but who for a year, started taking singing classes. After a year, his brain was analyzed and scientists found that he had increased blood flow to the temporal lobe. The changes were so clear after only a year.

These changes offer great advantages in the domain or of education. Musical education offers benefits in standard education as well. For example an increase in focus, and language, as well as mathematics.

These benefits can also go as far as to have health benefits. If music helps develop the brain, then it can help develop somebody's damaged brain.

This can be seen in stroke patients suffering from aphasia. They have lost the ability to speak or have poor language. They can go through **melodic intonation therapy**. What it does is that it teaches patients to speak using melodies. They are able to learn the melodies and slowly regain speech.

Patients suffering from dementia can also benefit from language, for example when they start remembering the melody of a song they used to know. It stimulates their hippocampus and they regain some memory.

Stroke patients or parkinson's patients are also helped through music. Through the rhythm of music some patients are able to regain motor skills.

Music has such a deep impact on the human brain that it can actually form or reform it, and establish or reestablish neuron connectivity. This shows the importance of music and its physical properties.

## **VI-Universality of Music**

Although we have talked about culture and the variety in music, there is some universality in music. Music might even be more evocative and efficient than language.

We can't help but wonder at how early a child notices music. Some have argued that a child learns of music as early as 17-19 weeks in the womb. This can be explained by the heartbeat of the mother and the sound of the blood flow. Already from the fetal phase the baby is subject to rhythm. This means that there is the universal beat which is learned before any culture can have an influence on the child.

Another interesting phenomenon is the recognition of consonance and dissonance at a very young age. An experiment was led by professor Sandra Trehub where a child had to choose between two environments, one with a consonant melody playing and the

other with the same melody but in dissonance. The child chose the environment with consonance every time. This shows the universal appreciation of consonance.

Also, despite culture, lullabies have always been present and performed by humans. An interesting thing about lullabies is the fact that they have similar structures despite the culture. They use slow tempo, limited and descending pitch, and soft tone. This is the same for any lullaby. It is the building of the child's musical education.

These are interesting findings because they show us that before a child can even speak, they can perceive music. This leads us to believe that music is in fact universal. If it is in fact universal, how long has music been part of mankind?

### B-Evolution and Music

Some argue that music has been imbedded in our genomes before man could even speak. One argument that supplies that theory is the findings of archeologist Nicholas Conrad. Him and his team have uncovered bone flutes dating back to 40 000 years BC. This instrument shows the understanding of music that our ancestors had.

Biologist Steve Mithen has also argued that our ancestors the Neanderthals were unable to speak but had already "mastered" music with the flute.

This makes us wonder why music has been with us for so long. If music has survived man's evolution, then it must have had an evolutionary purpose. This is a theory which has been expressed by Darwin. Darwin speaks about **sexual selection**. He claims that in order to attract the female, the male masters music among other things. This promotes the breeding of the species and therefore evolution.

Basically, a common theory is that with evolution of the brain, music has evolved and with the evolution of music, the brain have evolved. Mithen argues this and speaks of co-evolution between music and brain.

Although scientific research on music has only begun, there have been many interesting findings that help us understand such a complex notion. Through music we are able to realize just how much influence the brain has on the body and how much influence culture can have on the brain. The mysteries of why simplicity in mathematics is esthetically pleasing remains a widely debated topic, with mention of a certain "Golden Ratio". The intricacies of the human brain still trouble us and the fact that music is an intricate subject on its own does not help. Music seems to be particular to each individual as well as to each culture however there is a notion of universality in it. Music has such a powerful impact on humanity and offers so many benefits. The origin of music remains unknown and it has been greatly associated with language structure. Music has proved to be useful to evolution therefore explaining why 40,000 years ago our ancestors played music and today so do we. Some have even gone as far as to argue that the equation of the string vibration in the "Theory of Strings" is similar to the equation of vibrations of strings in an instrument, and subsequently claiming that music is at the heart of matter. We remain unsure of that. All we know today is that music has an impact on us which so far nothing else can compare to. Music is such a complex subject involving math, physics, biology, chemistry, neurology, and cognitive science. It spreads universally among cultures and through evolution.