Music and Medicine

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A number of publications have appeared dealing with diseases of composers. One may ask, why the interest? We all get sick, a matter of mainly personal interest. I suppose the fascination with diseases of composers stems from the belief that the disease influences or diminishes the creative ability and shapes the personality. We will see that this is, to a large extent, not the case. Some composers create music during their illness up to the last day of their lives. Another question concerns the relationship between creativity of composers to their daily life style; does creativity influence their daily existence? We will see that some composers lead ordinary lives, while others are consumed by their art. Finally there is the question of how the perception and creation of music influence neurological patterns in the central nerve system. This subject has recently received some attention because of the development of new imaging methods. These techniques help to answer the question whether perception of music is restricted to a specific neural network or affects various portions of the brain. There are other problems which can now be investigated, such as the difference in musician's central perception between absolute and relative pitch and how professionally trained musicians differ in their perception from

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the musically uneducated majority. I will try to answer some of these questions using selected examples of great composers and reporting on imaging studies published during last years which deal with the reflection of musical perception in the brain.

I. The Impact of Disease on Composers

I have often wondered about compartmentalization of the mind of some creative artists. In some cases, there is little overlapping between creativity and daily life. For example, it would be difficult to spot the musical creativity of a composer like Richard Strauss. Upon casual encounter, as I know from personal experience, he in no way exposed his genius during daily contact; he looked and behaved like a business man. But other composers were haunted by their genius. Thomas Mann, more than any other writer, believed in the relationship of genius to disease. In his book, Doctor Faustus, the story of a creative composer who willingly chose disease, he wrote,

"Was I not right to say that the depressive and the exalted states of artist, illness and health, are by no means sharply divided from each other? That rather in illness, as if it were under the lee of it, elements of health are at work, and elements of illness, working geniuslike, are carried over into health? Genius is the form of vital power deeply experienced in illness, creating out of illness, through illness creative." ¹

Bach

Johann Sebastian Bach was a solid citizen and family man with 20 children, 7 by his first wife and 13 by his second, of whom 9 died within the
five years of birth and most of them within a much shorter period of time. Of
the other 11, the majority seem to have remained unmarried. One of his
sons, Wilhelm Friedmann Bach who was a competent composer, became an
alcoholic. Another son Johann Gottfried Bernhard caused his father
considerable distress on account of debts and other irresponsible acts until
his death at the age of 24. \(^2\) Bach had political troubles with his superiors.
In a letter to the Leipzig town council in 1736, Bach complained of one of his
students, a man called Krause whom the Rector wished to "force upon me as
first prefect". Bach complained that the Rector wanted to appoint him
although, "myself recently made a test of his time, in singing class which he
failed so badly that he could not accurately give the beat in the two principle
kinds of time." In other words, the Rector tried to force him to accept the
student, whom Bach thoroughly disliked and who was musically incompetent.
In another letter to the elector of Saxony in Dresden, he wrote,

"for some years and up to the present moment, I have had the
Directorium of the music in the two principle churches in Leipzig, but
have innocently had to suffer one injury or another, and an occasion
also a diminution of the fees accruing to me in this office; but these
injuries would disappear altogether if Your Royal Highness would
grant me the favor of conferring upon me a title of Your Highness's
Court Capelle, and would let You Highness command for the issuing of
such a document go forth to the proper place." \(^3\)

In other words, Bach tried to write to the Elector, the eighteenth century
equivalent of the president of the university or the governor of the state
because of his political troubles he suffered in his own home town. These
were difficulties due to jealousy, because Bach was far superior to his musical
colleagues and teachers who disliked him and placed many political difficulties in his way.

Bach probably died of a stroke after an unsuccessful operation to remove a cataract from his eye 4.

**Mozart**

Mozart, like Bach, was disdainful of many mediocre contemporary composers, and his relationship with Salieri was not friendly, although the rumors that Salieri poisoned Mozart are certainly untrue. Mozart is now often described as a buffoon who used dirty language; but those who have been in Southern Bavaria or Austria know that scatology is not uncommon and is a way of expressing surprise or even pleasure.

In Mozart's case there was little compartmentalization of music and no separation of his creativity from his daily activity. It seemed as if Mozart's music penetrated his mind, regardless of what he was doing at the time, whether playing pool or just being quiet. His sister-in-law has described this after Mozart's death, in 1828,

"he was always good-humored but even in the best of humors still very pensive, looking you right into your eyes, giving a considered answer to everything, whether sad or happy, and yet at the same time he appeared to be deep in thought working on something completely apart. Even as he was washing his hands in the morning, he would go back and forth in the room, never standing still, all the while tapping one heel against the other and being lost in thought. At the table, he
seemed to be --- completely unaware and often scowling at the same time. Otherwise his hands and feet were constantly in motion; he was always playing on something as though it was a piano, for example with his hat, pockets, watch chain, tables, and chairs." 4

His brother-in-law described Mozart 4:

"when he was occupied with an important work, he not only spoke in distracted, confused ways, but he would also make jokes of a kind one did not expect from him, indeed, he would even deliberately let his behavior go. All the while, he seemed not to be thinking or pondering on anything at all."

And yet, despite his frequent illnesses, Mozart's creativity was not influenced by his disease. Even when ill, he composed. Even during the last days of his life, his musical creativity persisted. When he said to his sister-in-law, "I already have the taste of death on my tongue," he still worked on his unfinished Requiem, until his wife took the score away from him. But he asked for it and had it returned to him, and to the very last, he told his pupil how to finish this work. Even his final illness failed to damp his productivity, because of his incredible urge to create.

**Beethoven**

Beethoven's creativity was also not stilled by his illness. His deafness even appeared to make his compositions more otherworldly. As deafness descended upon Beethoven, in his 20 and 30s, he wrote, "it is a miserable life, I tell you; for almost two years now, I have avoided society completely for I cannot bring myself to tell other people: I am deaf". Then he continued, "and besides, what would my enemies, and I have a few say to that?" His friend,
Breuning wrote, "most of the time he is in a very dejected frame of mind." During the period of increasing deafness, he finished the fourth symphony, the Razumoviski Quartets, the fifth piano concerto, all showing the independence of his creative ability from his ill body. While Beethoven was in the throws of illness with severe fever and intestinal troubles, he wrote "Fidelio".

As far as his personal relations with others are concerned, Karl Frederic Zelter, who was an administrator and mediocre composer and a friend of Goethe, wrote of Beethoven, "I got to know Beethoven in Teplitz. His talent amazed me; only unfortunately, he is a complete raw personality who may not be wrong in finding the world a detestable place but certainly does not make it anymore enjoyable either for himself or others thereby". But Beethoven, when in the depth of disease and depression, wrote the Hammerklavier Sonata, with the slow movement a moving song of lamentation. He wrote his "Missa Solemnis" and his late piano sonatas, while he was "feeling very poorly".

Although Beethoven was admired by many including the Viennese nobility, he had enemies. Beethoven made no secretes of his dislike for them. The composer Louis Spohr a contemporary of Beethoven, is an example of the ignorance and jealousy which so often confront a genius during his life-time. As he wrote,

"I freely confess that I have never been able to relish the last works of Beethoven. Yes, I must even reckon the much admired ninth symphony among these, the three first movements of which seemed to me, despite some solitary flashes of genius, worse than all the eight
previous symphonies. The forth movement is, in my opinion, so monstrous and tasteless, --- so trivial that I cannot understand how genius like Beethoven could have written it." And he concludes, "Beethoven was wanting in aesthetic feeling and in the sense of the beautiful."

Schubert

Schubert's whole being, like Mozart's, was filled with the creation of music. There was no compartmentalization in Schubert's personality; his music penetrated his life, and like Mozart before him, he continued to work on his music up to his death from typhoid fever, correcting the proofs of the Winterreise. His father had no understanding for this and forbade his son to return home if he persisted in composing, a severe blow to the young Schubert; this found its expression in the form of an allegory, later titled "My Dream", which ends, "And I saw my father reconciled in loving. He closed me in his arms and wept." ⁴

Schubert acquired syphilis, and fell into periods of deep depression, overcoming it only by a frenzy of composing. As he wrote, "In a word, I feel I am the most unhappy, most wretched man in the world. Imagine a man whose health will never be sound again, and who in despair only makes it worse and not better; imagine a man, I say, whose most shining hopes have come to nought, for whom the bliss of love and friendship offers nothing but the greatest pain, --- and ask yourself if that this is not one wretched unhappy man? ⁴,⁵

In Schubert's case, disease became indeed a part of his art and penetrated it. Not disease, only death could silence him.
There are many examples which show that the creative spirit cannot be suffocated by disease. The "unasked for fountain of an idea", as Beethoven called inspiration, survives the most serious illness. The emotional content of good music does not depend on daily circumstances but stems from the depth of the "inner self" which can remain independent of outside circumstances.

II. The Brain and Musical Perception

I now wish to discuss the cognitive function together with local processes in the brain during perception of music. There are methodological and technical difficulties; music has many components such as timbre, pitch, and rhythm, and there is performing, listening, and sight-reading which may be processed and localized by the brain in different manners \(^6\). There seems to exist a degree of functional independence among the music processing components \(^7\). Music performance and music perception are localized in different neural networks as shown for sight reading and keyboard performance, or for melodic perception \(^8, 9\).

The main difficulty in exploring musical perception is technical. Science is hostage to techniques which are used to achieve its goal. Results are as good as the methods used. Let us consider for example the variety of techniques used to localize the hypothetical "seat of music" in the central nerve system.
Neurological Deficits and Music Perception

The classical way to study the relationship between music perception and its localization has been through neurological deficits, resulting from brain lesions resulting from disease or from the surgeon's knife \(^6, 10-12\). This method is not very exact and furnishes no information on the involvement of smaller areas. There are classical descriptions which show that aphasia (lack of verbal ability) and amusia (impaired musical ability) can exist as separate entities in patients after stroke. The composer Ravel is often mentioned as an example of the fact that aphasia and amusia are independent. Ravel's first symptoms of neurological dysfunction appeared in 1933 and consisted in difficulty in writing \(^13\). His friends noted spelling errors on the score of a piece that Ravel was composing. He was still in possession of his musical composition skills. By the end of 1933, he was no longer able to sign his name or read. Despite this he could express himself clearly and understand speech spoken to him; he did have difficulty finding proper names. He also developed inability to sight-read, to play by heart his own compositions, to name or write notes he heard. His illness therefore was a selective impairment of function underlying the translation of musical representation from one modality to another, such as from visual to motor or auditory; none of these modalities considered separately was impaired. We do not know the nature of Ravel's illness, but it has been speculated that there was local cerebral degeneration: the symptoms of agraphia (the inability to write), alexia (inability to read), and aphasia (lack of verbal ability) suggest specific disturbances in the posterior region of the left hemisphere, the temporal gyrus.
Other clinical examples of this dichotomy between aphasia and amusia exist. Luria \(^{14}\) describes the history and symptoms of the Russian composer, V. G. Shebalin who lived in the early part of the 20th century. Shebalin was a Professor at the Moscow Conservatory and had many illustrious pupils; Shostakovich was his friend. Shebalin had a series of strokes, the second one resulting in aphasia; he was unable to understand speech and could not speak. While this was going on, Shebalin suffered no significant alteration in musical ability. While aphasic, he finished compositions which he had started to write before he was taken ill, and he created a series of new compositions which Shostakovich called "brilliant creative works \(^{14}\). "

In a more recent study, it was shown that removal of the temporal lobe for intractable epilepsy revealed missing pitch perception in subjects in whom Heschl's gyrus, that is the auditory cortex, was removed \(^{10}\). It was also found that patients with temporal lobe excision of the auditory cortex experienced significant deficiency in melodic discrimination \(^{11}\). 

The general information from these clinical observations is that music involves specific but different interconnected domains in the central nerve system and that music perception is not at all homogeneous; music performance and music perception represent different sensory and motor functions with different reflections in the brain.
**Scanning and Imaging**

**PET Scan**

PET scan is based on the use of positron emitters (positively charged electrons). It measures metabolic activity of individual portions of the brain through the uptake of radioactive deoxyglucose and also determines cerebral blood flow in different localized areas. We first explored the use of coincidence counting in determining coronary flow \(^{15}\). After the injection of \(^{15}\)O water bolus, increased local radioactivity denotes an increase in blood flow \(^{10}\). The images can then be localized by fitting them onto anatomical pictures by means of either stereotactic preobtained picture or by superimposing them on magnetic resonance imaging pictures. The cerebral structures involved in the appreciation of music can then be identified \(^{7}\). This is referred to as subtractive PET (it subtracts the obtained images obtained by PET scan and superimposes them on matched MRI scans). Some investigators also studied the different neural structures involved with music components of timbre and rhythm. Not surprisingly, Platel found that timbre and rhythm activate different neural networks \(^{7}\). Sergant \(^{8}\) studied the CNS localization of sight-reading and keyboard performance. She and her co-workers found that the individual components such as playing, listening to music and reading music engaged specific cortical areas \(^{8}\). Tonal pitch information was primarily located within the frontal and temporal cortices, while in passive melodies the right occipital cortex was involved \(^{9}\).

Zatorre also used subtractive PET to study the changes in blood flow upon listening to the melodies, relative to acoustically matched noise sequence. Listening to the first two nodes of each melody resulted in right
frontal-lobe activation. Zatorre concluded that specialized neural systems in
the right superior temporal cortex participate in central analysis of melodies,
while pitch comparisons appear to be expressed via a neural network that
includes the right prefrontal cortex. Of particular interest are the subtle
differences in effective neuronal networks between musicians with absolute
and relative pitch. Using the radioactive water ($^{15}$O) injection it was
found that the most remarkable difference between musicians with and
without absolute pitch was in activation of the left posterior dorsolateral
frontal cortex (DLF), the region which has been implicated in conditional
associative learning of sensory stimuli. However while DLF area was only
active in the absolute pitch group in the tone condition, it was also activated
when relative pitch was demanded (distinction between minor and major).
Why some people have absolute pitch is not certain but Zatorre believes that
it results from an interaction between computations in the superior temporal
area plus networks particularly in the DLF cortex.

Of particular interest to those of us who compose music, that is who
image it in their mind's ear before committing it to paper, are PET scans
comparing images obtained by imagining versus perception. Imagining
music in ones head is what might be called "thinking music", while perception
is the response to an outside music stimulus. Some results obtained by
Zatorre, show the comparison of imagining and of perceptual task where
there is both an increase in blood flow in the inferior frontal parietal cortex
and right thalamus and when there is a quantitative difference in flow. They
speculate that this network of regions is specifically associated with retrieval
and generation of auditory information. Here again a multiplicity of
networks are involved. While all subjects did much better on the perception task, compared to imagery, results are not very different except in intensity.

**Functional Magnetic Resonance Imaging (fMRI)**

Functional magnetic resonance imaging (fMRI) is based on the paramagnetic effect of deoxyhemoglobin which acts as an endogenous contrast agent. fMRI is particularly useful for non-invasive mapping of hemodynamic sequelae of neural activation. It also makes possible blood/oxygenation measurements in a clinical imager\(^\text{17-19}\). The method has high spatial resolution and avoids the use of ionization. The advantage of functional magnetic resonance over PET is that in the former multiple and repeated studies across a single area can be made\(^\text{18}\).

Another approach to map the function of the human brain is by means of magnetoencephalography\(^\text{20}\). This method measures the activity of neurons resulting from ionic currents across cell membranes. The technique offers complementary composite measures of a large number of neurons that may be active simultaneously, with spatial resolution in the subcentimeter range and temporal resolution in the milliseconds.

A number of imaging studies using fMRI on humans have described sound-evoked chronic activity\(^\text{21}\). Even auditory regions in the brain stem can be imaged by this technique\(^\text{22}\). Guimaraes delivered music through a headphone to the subject. Imaging of subcortical regions could be accomplished by cardiac gating, that is by taking pictures only during a particular phase of the
cardiac cycle. This eliminated the effect of pulsatile brain stem motions. It was found that responses were localized in the classically-defined auditory projection nuclei, the cochlear nuclei or the superior olivary complex. Of interest, the group headed by Pantev found remarkable differences in functional magnetic source imaging between musicians as compared to the controlled subjects who had never played an instrument.

Using functional magnetic imaging to measure cortical representation in highly skilled musicians, it was found that the dipole moments for piano tones, but not for pure tones of similar fundamental frequency matched in loudness, were enlarged about 25 percent in musicians compared with controlled subjects who never had played any instruments. This correlated with the age at which musicians began to practice. This phenomenon applied to musicians with both absolute and relative pitch. Pantev et. al interpreted these findings as indicating that musical experience during childhood influences structural development of the auditory cortex.

Elbert et. al furnished further evidence that afferent impulses can induce plastic reorganizational changes within the adult mammalian central nervous system. They described that the cortical representation of the fingering digits of the left hand in string players was larger than in controls. There were no significant shifts for the digits of the right hand of the musicians compared to those of the controls. In string players who had begun to play at an early age, cortical reorganization appeared early. Such a plastic reorganization of the cortical space might permit rapid allocation of available CNS circuitry and would confer obvious practical advantage, since it might play a role in the recovery of function.
FINALE

Art is the expression of ideas by technical means. An idea by itself has little value unless it is transformed into a work of art. Therefore, I consider as nonsense the statement, which one hears occasionally, that Raffael would have been a great painter even he had been born without hands. Indeed, an idea that cannot be expressed is worth nothing. That is also the case in science, where ideas only count if they find experimental proof. The saddest cases in art are those artists who feel but are not able to give expression to their feelings, or the artists who labor without an echo, who find no recognition by their contemporaries.

The transition from the purely physical, biological domain as documented by measurable changes in the brain, to what we call "music", is a giant step. It is a step which separates the disembodied mind from the physical brain. Before that transition, the rules of biology apply. But once the step has been taken, we enter a territory inhabited by confines of the unconscious, by love and hate, by tenderness and brutality, by faith, and finally by art. All the measurements of blood flow, action potentials, oxygen usage and nerve transmitter substances cannot explain what we feel when we listen to music. How can increased blood flow in a specific region of the temporal lobe explain how we perceive the resignation expressed in Beethoven's sonata Opus 111, the beauty of a Mozart's piano concerto, the profound faith in Bach's B minor Mass or the immense depth of Mozart's Requiem? No physical phenomena can ever explain it. Music is truly disembodied. It is the only art form which needs neither words nor images to
convey its meaning. As Beethoven has written in his score of the Missa Solemnis, "from the heart—may it again go to the heart". Musical perception and its emotional impact belong to different worlds. One is measurable, and the other is indefinable. Music, beyond its physical confines, becomes the bond that connects us to the unattainable and the eternal.
References


