MOZART EFFECT: an assessment based on cognitive science and biocomputing

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Don Campbell, a music teacher and famed music therapist, wrote a best seller "*The Mozart Effect: Tapping the Power of Music to Heal the Body, Strengthen the Mind and Unlock the Creative Spirit*." This book is controversial. An assortment of diverse reader comments can be viewed at the website of Amazon.com (simply search for "Mozart Effect" and "Don Campbell"). The reviews range from very good to very bad. One of the reviewers even changed his/her view from a 5-star rating to 1-star over the years ("The Mozart Effect" is really "The Movement Effect" posted on April 1, 2000). Here are a few sample comments: "This book was absolutely excellent!", "A powerful contribution explaining the power of music!", "Regrettable pseudoscience", "Disappointingly un-scientific". A reasonably balanced and professional review was presented by Kevin Kinney, Ph.D., Charlotte, North Carolina, July 16, 1998 "Provocative, but not conclusive."

Campbell's book covers three areas: a) healing the body, b) strengthening the mind, and c) unlocking the creative spirit. I will focus on the third topic, since I have some biased opinions about the creative process, and since presently I have no expertise to deal with the other two topics.

I agree to some of the author's opinions, disagree to others, and found that the remaining opinions could be modified, further elaborated, and made more specific. Of course, my opinion should be treated as speculation. My opinion is an extension and inference of my current understanding of the creative process. Some of my points are experimentally testable (i.e., scientifically falsifiable); others may remain speculative for a while. At present, I am inclined to believe that the Mozart effect is real. I further suspect that the effect may be restricted to only late Mozart music, rather than all Mozart music. The division of the early and the late Mozart music is of course somewhat arbitrary, and also very subjective and inherently problematic. Mozart did not suddenly switch his style when he woke up in a special morning. Roughly speaking, if Mozart's regularly numbered symphonies (Nos. 1 - 41) are divided into two halves, the high numbers can be treated in this discussion as the late Mozart and the low numbers the early Mozart. Thus, even his first symphony shows the rudimentary trait of Mozart's style. But a comparison of his *Symphony No. 1 in E-flat Major (K. 16)* with any of his last 8 symphonies provides a sharp contrast. Please note that some Mozart symphonies with numbering beyond the original 41 are actually early symphonies. Incidentally, Sir Neville Marriner (Academy of St. Martin-in-the-Fields) conducted a two-box set of Mozart's symphonies, with one labeled Early Symphonies, and the other labeled Symphonies 21-41.

Let us first see what Don Campbell wrote about the Mozart Effect. As some of the critics validly pointed out, Campbell mixes scientific evidence with anecdotes. It is customary for modern scientists to dismiss and ignore anecdotes. In my opinion, anecdotes are useful hints and clues, and should be treated with both *skepticism* and *curiosity*. Campbell's writing style might also appear to be problematic to scientists who are accustomed to tasteless, "clinical" and emotionless writing of scientific articles. Like novelist Arthur Koestler, the author of *The Act of Creation* (a fascinating book about creativity in science, art, and humor), Campbell tends to mix poetic statements with terse science-like statements. He switches between these two modes of writing without much self-awareness, thus turning off some science-inclined readers. However, if one can flexibly assign varied weights to Campbell's statements as one reads on, one can extract some valuable information from Campbell's book.

Unlike many science professionals, who usually start a critique by determining whether the sample size was large enough to warrant a statistical analysis, I will take a more forgiving attitude. It seems to be a foolish attitude to ignore or dismiss this book simply because Campbell did not approach the problem with rigorous scientific methodology and write the book in a rigorous scientific style. Lessons from science history abound: many poorly executed experiments led to valid conclusions, which were subsequently confirmed by rigorous investigations. On the other hand, some rigorously executed experiments gave misleading or wrong conclusions because a key factor was inadvertently neglected. For the time being, I will give full benefit of the doubt to the cited experimental results, especially those of Rauscher and her colleagues. But, unlike some of Campbell's critics, I will make a separate assessment of the validity of **results** of experiments and observations, and the validity of **explanations (interpretations)**. Again from lessons in science history, it is possible that the observed effect may be real, but the interpretation may be wrong. We should not throw the baby away along with the tub water.

The following are summaries or verbatim quotations from Campbell's book (quotation marks omitted for convenience):

> In Chap. 1, p. 15. , Campbell cited a study by Frances H. Rauscher, Ph.D. and her colleagues, in which 36 undergraduates from the psychology department scored eight to nine points higher on the spatial IQ test (part of the Stanford-Binet intelligence scale) after listening to ten minutes of *Mozart's Sonata for Two Pianos in D Major (K. 448)*. Although the effect lasted only ten to fifteen minutes, Rauscher's team concluded that the relationship between music and spatial reasoning was so strong that simply listening to music can make a difference.
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> Gordon Shaw, a theoretical physicist and one of the researchers, suggested after the Rauscher results were announced: "[Mozart's music] may 'warm up' the brain." "We suspect that complex music facilitates certain complex neuronal patterns involved in high brain activities like math and chess. By contrast, simple and repetitive music could have the opposite effect."

Well, Rauscher's generalization of the effect to *all* music may be premature. But I would not dismiss the claim in a whole sale manner. Perhaps, the particular style of Mozart music made a difference. Shaw suspected that the may be restricted to Mozart's music but not all music. But Shaw's interpretation was too broad and too non-specific.

Interestingly, according to the book, the day after the Irvine findings were reported, music stores in one major city sold out of Mozart recordings.

Appropriately, the book did address the specific problem "Why Mozart?" on p. 27. Why NOT the Bach effect, the Beethoven effect, or the Beatles Effect?

Does [Mozart's] music have unique properties, eliciting universal responses that only now are yielding to measurement?

Here is Campbell's own interpretation:

> Clearly, the rhythms, melodies, and high frequencies of Mozart's music stimulate and charge the creative and motivational regions of the

> brain. But perhaps the key to his greatness is that it all sounds so pure and simple. Mozart doesn't weave a dazzling tapestry like that great mathematical genius Bach. He doesn't raise tidal waves of emotions like the epically tortured Beethoven. His work doesn't have the stark plainness of a Gregorian chant, a Tibetan prayer, or a Shaker hymn. He doesn't soothe the body like a good folk musician or slam it into motion like a rock star. He is at once deeply mysterious and accessible, and above all without guile. His wit, charm, and simplicity allow us to locate a deeper wisdom in ourselves. To me, Mozart's music is like the great architecture of Moghul India -- the Amber Palace in Jaipur, or the Taj Mahal. It is the transparency, the arches, the rhythms within the open space that so profoundly stir the human spirit.

He then cited Alfred Tomatis, M.D., a French physician, whose research — Campbell claimed — has established the healing and creative powers of sound and music in general, and the Mozart Effect in particular:

> Although Mozart shares affinities with Haydn and the other composers of his period, Tomatis asserts in *Pourquoi Mozart?* (Why Mozart?), "he has an effect, an impact, which the others do not have. Exception among exceptions, he has a liberating, curative, I would even say, healing power. His efficacy exceeds by far what we observe among his predecessors..., his contemporaries, or his successors."

My preliminary comments are as follows:

When Campbell starts the sentence with "Clearly," he perhaps means "Apparently," because a speculation cannot be in a state of "clearly"-ness. Campbell also mixes his explanations with his emotional outpouring of praise of Mozart's music. He wanders off the track unconsciously (or uncontrollably) but does remember to get back on track. Campbell offers an interpretation of the observed results which he believes to be true. But his explanations are too general, too vague, and sometimes even too mystic. But, over all, I would say, Campbell is not terribly "OFF the wall." Several times, the notion of *spatial* and *temporal pattern* was mentioned but not elaborated. In Rauscher's report, the cognitive improvement ascribed to the Mozart effect was shown to be *spatial reasoning*; the spatial IQ test of the Stanford-Binet scale was used in the experiment.

The notion of "temporal pattern" is easy to comprehend because rhythm is an important element of all music. The notion of "spatial pattern" however contains insight which may not be obvious to casual readers, because, unlike paintings, music is a temporal art, rather than a spatial art. The report becomes comprehensible if we invoke the notion of *parallel processing* and *pattern recognition* — terms borrowed from artificial intelligence (AI). Thus, rhythm is temporal patterns, whereas harmony and counterpoint are "spatial patterns" because each constituent note in a chord or each melody in a polyphonic exposition must be "heard" concurrently with others, thus eliciting parallel processes in the brain. Needless to say, viewing a piece of painting also requires parallel processing (cf: the notion of *Gestalt* of Gestalt psychology; Gestalt = form in German). I regard harmony and counterpoint as "spatial patterns" for the following reason. Melodies or rhythms are temporal pattern, because the notes are dishing out one at a time, in a sequential manner (*sequential processing* in AI jargon). In contrast, the music notes constituting harmony and counterpoint must be stored in the short-term (working) memory and be spread out "spatially" in the limited "space" of the working memory; processing information contained in harmony and counterpoint requires parallel processing.

I will now attempt to fit the above observation into the frame work of my current understanding of creative problem solving. As a brief recapitulation, I specifically emphasize, among other models, the 'chance configuration theory' of Dean Simonton.

In Simonton's interpretation, a scientific discovery process involves three phases. Phases I and II are exploratory search of possible solutions and recognition of possible "match" between the solutions and the proposed problem, respectively. It is like fitting many different *templates* to a given *pattern* of the problem, or fitting a whole bunch of keys to a given key hole. Phase III involves a rigorous process of verifying the presumed match between a chosen solution and the given problem.

I then cast Simonton's theory in the framework of artificial intelligence. Phases I and II corresponds to processes of "parallel processing" -- ostensibly the task of right cerebral hemisphere, whereas Phase III corresponds to processes of "sequential processing," which, like verbal ability, is a specialty of the left (dominant) cerebral hemisphere. Pattern recognition requires matching of the whole pattern, and the fit must be a somewhat *loose* one instead of a tight fit. In contrast, the step of verification needs to be done strictly in words or rules of logic, and is thus a sequential process.

This interpretation works well with Henri Poincaré's remark "it is through intuition we discover, and it is through logic we prove." Intuition (involved in Phase I and II) is related to *loose* pattern recognition and is therefore hard to describe verbally. Just try to describe in pure words a Rembrandt's painting and see if the imagery can be conveyed *verbally* to someone who has never seen the particular painting before. In contrast, proof or verification is usually verbal or written in the format of a sequential logic statements.

Particularly relevant to the above view was Mozart's letter written in ca. 1789: "... my subject enlarges itself, becomes methodized and defined, and the whole, though it be long, stands almost complete and finished in my mind, so that I can survey it, like a fine picture or a beautiful statues, at a glance. Nor do I hear in my imagination the parts successively, but I hear them, as it were, all at once (*gleich alles zusammen*)...... committing to paper is done quickly enough, for everything is, as I have said before, already finished."

Although Mozart did not use the jargon of artificial intelligence, he clearly stated that the crucial part of the processes was "parallel processing" (*gleich alles zusammen*), rather than "sequential processing." He nevertheless had no trouble "serializing" his music, as was shown in the movie "*Amadeus*" when he dictated the "*Confutatis*" section of his *Requiem*, one line at a time (or rather, one instrument or one voice at a time), to Antonio Salieri, his quintessential nemesis and rumored murderer. The movie eloquently demonstrated how serialized orchestral scores were reconstructed into parallel presentation of the music.

With this understanding or bias, I do not have to search or guess blindly for possible interpretations of the Mozart Effect but rather concentrate on Mozart music's possible effect of enhancing the parallel processing capability. As mentioned earlier, Campbell's book alluded to *spatial* patterns, as well as the function of the right brain. So his interpretation was close to what I have in mind but he did not elaborate it in a manner that is stripped off the coating of mysticism. Nor did his interpretations suggest how the effect can be custom-tailored and exploited to solve specific cognitive problems. On the other hand, Campbell mentioned, in several occasions, that the Mozart effect includes increased *attention*. I suspect the effect on "*divided*" attention may be more significant than on [highly focused] attention alone. I regret that the cited researchers did not pay attention to the possible enhancement of the ability of "divided" attention.

From my own understanding the creative process, excessively focused attention may be detrimental to creativity or problem solving ability, because exploration and search possible solutions are severely restricted to *well trodden* paths, thus precluding novel discoveries or novel solutions. While attention is important, the ability to simultaneously pay attention to several concurrent events (parallel processing!) is of paramount importance in creative processes.

So, what is so special about Mozart's music that is conducive to the development of parallel processing capability?

One of the reviewers, who changed his/her rating from 5 stars to 1 star over the years, disappointingly dismissed the effect as mere "general sensory stimulation." While undoubtedly all music has the general and non-specific effect of sensory stimulation (well known facts in developmental psychology), it does not preclude the possibility that Mozart's music, or at least, some of Mozart's compositions, have the additional effect of developing parallel processing capability — a specific effect. I mean, Mozart's music could have a general effect shared by all sensory stimulation and a specific effect which is unique to Mozart's music.

I now speculate that some of Mozart's compositions do have the additional specific effect — the effect of enhancing parallel processing capability. But the effect may not be present in all Mozart music. I found some peculiarities in Mozart's late symphonies that may be conducive to the enhancement of parallel processing capability. The effect is primarily an enhancement on the capacity of the short-term (working) memory instead of the long-term memory. Most people regard the capacity of the long-term memory as the primary determinant of cognitive abilities. I personally hold a different opinion: the short-term memory may be more important in creative problem solving than the long-term memory, unless the long-term memory is pathologically impaired.

My idea emerged while I was recently listening to Christopher Hogwood's recording (Academy of Ancient Music) of *Symphony No. 38 in D Major* (*K. 504*; also known as *Prague Symphony*). I will thus use the first movement of this symphony to illustrate the unique features of Mozart's late symphonies that may enhance parallel processing capability of the listeners (see attached file Prague.doc). But the features are also evident in the overture to Mozart's opera "*The Magic Flute*" (see attached file Magic.doc).

A digression of the classical music forms will set the stage for our subsequent discussion. The structural format of symphonies was largely developed through the effort of Mozart's contemporary and predecessor Joseph Haydn. The first movement of a symphony is usually in *sonata form*. The first movement of Prague Symphony is a typical example.

Prior to Haydn and Mozart, major composers such as J. S. Bach, G. F. Handel wrote their music mainly in *polyphonic* forms. A typical example is the *fugue*, in which several melodies run concurrently and sometimes run with an offset of timing (e.g., starting one measure late).

The following is an excerpt from David D. Boyden's *An Introduction to Music*:

> The fugue is a complex expression of polyphony. In polyphonic music, the melody and the accompaniment are inseparable because the melody is also the accompaniment. The melody appears in different part of an

> ensemble of instruments or voices, and each instrument/voice takes turn to accompany one another.
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> The sonata form is developed in response to the needs of a new type of texture, a harmonic-melodic one in which key and key change play a decisive part. In the fugue, the texture and the melodic material are the unifying elements; variety is achieved by the interplay of the subject (or answer) in the different voices and by proceeding through different tonalities. A simple music idea is thoroughly exploited by contrapunctual means. The sonata form, on the other hand, depends more fundamentally on harmony than on polyphony.
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> In brief, in the fugue, the melody is accompanied by counterpoint of the same melody offset in timing or of a modified melody, whereas, in the sonata form, the melody is accompanied by chords.

The first movement of a symphony is usually in the sonata form. Typically, it begins with a slow passage of *introduction*, which is then following by a fast *allegro* part. The *allegro* part are divided into three section in the format of A-B-A, or *Exposition*, *Development* and *Recapitulation*. Often a *Coda* follows the Recapitulation section. In Haydn's or Mozart's symphonies, the Exposition section contains at least two distinguished themes — pleasant melodies that can be recognized by untrained ears as song-like and memorable tunes rather than some brief and "unstable" transitional passages. There are usually sufficient repetitions so that even untrained ears can recognize and remember them at least for the duration of the movement. Transitional passages have less repetitions and are therefore less memorable.

The main theme (or themes) of the Exposition section is usually in the same key as the designation of the symphony. For example, Prague Symphony is also known Mozart's symphony No. 38 in *D Major*. The *main theme* is thus in D major. Mozart was known to be generous; he often presented more than one melodies in the main theme section.

Following the main theme section, there is usually a change of key before the arrival of the *second theme* (or themes): from tonic to dominant key in major keys, and the tonic and the relative major in minor keys. For example, the second theme in the first movement of Prague Symphony is in A major instead of the original D major.

The Development section is the playground for the composer to show off the compositional skill as well as to agitate the listeners' emotion, by playing with various themes in different variant forms, combinations/recombinations — sort of free-spirited excursions. At the end of the Development section, transitional passages prepares the mood for the return of the main theme and the remaining part of the Recapitulation section.

The Recapitulation section, by definition, recapitulates what has been presented in the Exposition section. But the repetition is not exact. Notably, there is usually no key change in the second theme. In the Recapitulation of a typical symphony, both the first and the second themes are in the same key (D major in Prague Symphony).

In the sonata form, the melodies of the two themes are emphasized and form the conspicuous parts of the musical exposition. The choice of a particular instrument for playing the themes allow the musical "ideas" or music "thoughts" to be expressed in different tone qualities (e.g., violin sound as opposed to flute sound). The remaining instruments form the *supporting role* of accompaniment by providing the harmony. In the simplest form of symphony, the listeners need only to pay attention to the thematic melodies, whereas the remaining sound is heard as harmony in the background. There is a distinct difference in the dominant and the subordinate roles played by the theme and the harmony, respectively. For non-musicians, the harmony need to be heard as "a whole" since different chords and different styles of harmony can be perceived as different "tone patterns" — there is no imperative need to be able to name and remember each individual note that constitutes a chord or the harmony. When a violin is tuned by the musician prior to the performance, a *perfect fifth interval* is used as the criterion of being in tune; each string is thus not tuned individually but rather two strings are tuned at a time and the sound pattern is heard as a whole. In brief, there is no demand for "divided" attention from average listeners in an average symphony from the classical period. Thus, I suspect that hearing the harmony or chords alone cannot substantially enhance the parallel processing capability. Apparently, Mozart offered much more.

Mozart's late symphonies offer more and demand more of the listeners' parallel processing than symphonies of his contemporaries. Mozart often provided more than one main themes and more than one second themes (Boyden's book alluded to that quality as Mozart's "generosity"). Furthermore, he sometimes ran two or more melodies *concurrently* rather than *successively*. The concurrently running melodies do not usually lend themselves to be categorized as either dominant or subordinate, primary or supporting. Often both melodies appear equally attractive, or, at least, both take turn to catch the listeners' keen attention, thus naturally demanding "divided" attention of the listeners. Sometimes, as shown in Prague Symphony, Mozart even presented two distinct *rhythms* concurrently (see file Prague.doc). In other words, Mozart's late symphonies provide ample opportunity for average ears to practice parallel processing; the listeners are lured to the practice without much conscious awareness in part because the music is so attractive. By necessity, the listeners must place all concurrently running melodies in the short-term memory, thus, at least temporarily, giving up the habit of a "one-track mind." It is hard to imagine that prolonged training as such will *not* have an effect on the mind's spatial capability.

This demanding feature sets Mozart's late music apart from his early music and also from music of his contemporary Antonio Salieri. Through my limited exposure to Salieri's music, I have formed an impression that Salieri's music is similar to Mozart's early music but not the more mature late compositions of Mozart. I suspect it is this peculiar quality of Mozart's late symphonies that is primarily responsible for the enhancement of creative power and the enhancement of spatial temporal performance caused by the Mozart Effect.

If the above explanation is valid, why doesn't polyphonic music of Bach give rise to the same effect? Why doesn't the music of other more recent composers which also present a number of concurrent themes achieve the same effect?

I believe it might have something to do with the relative simplicity and the extraordinary charm of late Mozart music. In spite of the extraordinarily ethereal quality of Mozart's music, Mozart was really a composer for the *common folk*, rather than for the elite. As an example for the contrast, I recently spent some time on Richard Strauss' opera *Der Rosenkavalier*. In my attempt to follow the orchestral score while I was listening to a CD recording, I actually got lost several times while I listened and viewed the score at the same time; I was simply overwhelmed by its complexity. The situation of course improved substantially after my repeated exposures and practices. But then I was also surprised to find that I had not detected the presence of some concurrent themes (melodies "running in parallel") until I read the orchestral score *visually*. In contrast, Mozart's concurrent themes are hard to miss with and without the aid of the orchestral score; they are instantly recognizable and memorable, thus luring the listener's attempt to keep "parallel" track of the music exposition. It is perhaps this peculiar quality that makes the Mozart effect more easily detected in [late] Mozart's music than in other composers' music. I do believe that "serious" attempt to thoroughly study *Der Rosenkavalier* could also enhance the parallel processing capability, but one could hardly detect the effect by casually playing the music to a group of experimental subjects from a pool of psychology students, with which Rausch and colleagues did the experiment cited above. Likewise, polyphonic music of Bach and Telemann, for example, could enhance the parallel processing capability in professional or semi-professional musicians. This is especially true for the members of a chamber music ensemble group. After all, the ensemble members have to be able to perform "parallel processing" before they could play the music successfully in a sensible manner; they must keep track of others' performance at the same time when they pay attention to performing their own "duty." Normally, such a parallel processing "duty" is left to the conductor alone. But, in my opinion, this type of polyphonic music is simply too demanding on average ears to have any dramatic Mozart effect.

Finally, I could not help notice a distinct correlation between the Asian music and the contributions of Asians to original science and innovative technology. It is undeniable that Asians have contributed relatively little to original science and innovative technology. Asian music also tends to be monophonic (and monotonic) and lacks [local] diversity. I mean, the diversity of Asian music tends to be linked to ethnic differences only. There is little diversity of the music within a homogeneous group; whereas diversity in western music links to the difference in the period (e.g., classic era vs. romantic era) and the personality of the composers (Beethoven vs. Schubert).

Notably, harmony and counterpoint are not parts of Asian music; music played by an instrumental ensemble tends to be *in unison*. In other words, Asian music does not demand parallel processing capability of the listeners. The positive correlation between the nature of Asian music and the Asian contribution to science and technology is therefore not surprising. What remains to be determined is: which one is the cause and which one is the effect? Or, are both [science and music] the consequence of the same common factor?

Asian cultures emphasize conformity and discourage diversity. As students, I was often instructed not to foster divided attention ("one mind should not be used concurrently for two independent tasks"). Youngsters are often instructed not to "think erratically and aimlessly like the "Northern" barbarians." Thus, cultural pressure tended to foster a one-track mind. The cultural trait is especially prominent in highly educated people, presumably because they are the survivors of a long series of "conformity" tests, known customarily as examinations. The emphasis on conformity also tends to foster rule-based reasoning and obedience to authority opinions, thus eliminating curiosity and the exploratory habit which is common even among animals (my daughter's dead cat Niaomi was highly exploratory and sometimes appeared to be smarter than our average medical students.). Eventually, a conformist relinquishes personal opinions and independent judgment.

Of course, the above analysis may be oversimplified, since creativity also depends on traits other than the exploratory instinct and the skill in parallel processing. Differences in social values and cultural practices could also be a major factor. For example, Asian people's face saving habit is detrimental to creativity. Thus, even if one has a phenomenal parallel processing capability and curiosity, the sheer face-saving instinct prohibits risk-taking and prevents ventures into uncharted waters, thus depriving the "victim" of the opportunity for innovation and discovery.

In closing, I would like to repeat the emphasis that this is only my speculation — an attempt to provide an explanation of the possible Mozart effect. However, my explanations are sufficiently specific to be experimentally testable — I mean, it is in principle to prove that my explanation is wrong; assertions, such as "Mozart's music is pure," that is impossible to be proven wrong does not belong to the realm of science. Our educational system tends to discourage "speculations." Every time you offer a speculation in an attempt to explain some observations, others will tell you: "Don't jump the conclusion." Ironically, many widely accepted explanations are no more than speculations by well respected authority, because, more often than not, the orthodox explanation may not be the only plausible explanation, and sometimes the orthodox explanation eventually turned out to be wrong, or inadequate, or not sufficiently general. Yes, the Mozart effect is provocative but not conclusive. So, let us all offer some speculations. Some well-meaning investigators may do critical experiments to test these speculations, thus eliminating the weaker ones.

In view of the deteriorating educational system, both in the U.S. and elsewhere, it is my hope that the Mozart effect provides some clues as well as remedies which may help to undo the formidable mental barrier and mind-bondage fostered by old cultural habits and/or conformity-style education.

Additional Remark:

There is an anecdotal observation passing around in the computer programmers community: many skillful computer programmers have formal training in music. My speculation is: both professions require parallel processing capability and a good short-term working memory. It may sound strange to say "parallel processing" in view of the fact the computer programs are sequential instructions. But a competent programmer must be able to put many different possibilities in the short-term memory and to be able to scan these possibilities *at a glance* in order to avoid unplanned conflicts (which are usually known as computer "bugs") (*gleich alles zusammen*). It is no wonder that Campbell referred to Bach as the *mathematical* genius (see above quotations from Campbell's book).