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Chaos and Music
Chaos und Musik, Chaos a hudba

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About chaos theory

It seems that the end of the 20th century brought new knowledge (is it possible to speak of a different perspective?) - that the constant process of "understanding" in the classical sense as was sketched out in its vision in daringly mechanical and rational concepts by the thinkers of the 18th century and their followers, shows - placed face to face with today's reality - considerable cracks. Filled with endless optimism that the possibilities of the human spirit, regarding studies of natural laws and the functional rules in all and sundry branches and fields of social history, are unlimited, we have reasoned that based on the understood it can be rationally projected in the near and distant future in the development of things that all will be understood, it is merely a question of time. Life experiences, however, day by day, more than any other earlier period has convinced us of the naiveté of this viewpoint. We are finding that everything functions again and again a little bit differently than that, even to the best of our beliefs, understanding and mental powers expect. In discussions of this subject all and sundry contexts come into play; many with a touch of certain trends and sensation, others quite serious and with great importance. Such expressions are "the end of history", "crisis of science", "postmodernism and "globalization." In the surroundings of these ideas is found, as well, **chaos theory**. What is this all about?

Chaos theory is undoubtedly a significant advance in contemporary science. It is a mathematic discipline (in a general sense - philosophical) centered on the study of so-called **non-linear dynamic systems**, that is complex phenomena, their development in the course of time which is difficult to predict. In this type of system can be such items as weather, capital markets, turbulence, the growth and development of live organisms, eco-systems and their development processes, the frequency and occurrence of earthquakes, languages and their development, the origination and spread of epidemics... As is apparent from some of the presented examples, the awareness of the chaos phenomenon and its genesis of the theory came about as a part, respectively on the spur of many scientific disciplines, of research into all and sundry facets of reality of natural and societal

forms: meteorology, economics, physics, linguistics, demography, chemistry, biology, ecology, geology, anatomy, prognostics, astronomy and others. The rise of the theory itself as a new view of reality is connect first and foremost with the name of a versatile American mathematician Benoit Mandelbrot (born in 1924 in Warsaw, Poland, childhood spent in France, studied in France and The US., Economics lecturer at Harvard, Engineering at Yale and Physiology at Einstein Medical College!) in the period between the 1960 and 1980. Further pioneering of this theory was by the meteorologist Edward Lorentz, mathematicians Stephen Smale and Mitchell Feigenbaum, biologist Robert May, physiologist Bernard Huberman, mathematician and physicist Robert Shaw, chemist and physicist Ilya Prigogine, geophysicist Christopher Scholz and others. **Chaos Theory does not analyze chaos as a course of events, devoid of order, rather the opposite - as a definite unrecognized, until now, form of order. As is shown, this is the way to understand the true order of nature.** It can be stated that it is possible to distinguish manifestations of chaos statistically, kinematically and dynamically (we reason that it regards the point of view from which the system viewed).

As will be evident from the following text we have many good reasons for the opinion that among the above-mentioned scientific disciplines there is also room for music theory (music theory we understand as a musicological discipline focused on music structure, and also, on the research of systematic, analytical and compositional technology areas of music expression. It is possible to say that the relationship of music theory to musicology is analogous to the relationship of linguistics to literary scholarship). A justifiable question here could be; why hasn't music theory figured in among the above-mentioned disciplines? The reason for this exception can be understood. We ask how many music theorists are there in relationship to mathematicians, physicists, economist. This question begs a further - What percent of "classical wisdom" analytical mathematicians, physicists, economists etc. have dare to enter into the "bizarre and fantastic" field of chaos research?

Let's return to Benoit Mandelbrot. It is known that from the beginning he was dissatisfied with deeply formal classical theory. He was agitated by its discrepancy with the real world. He was interested in those minor deviations in which theory varied from reality and those from which those theories, in their consideration, were abstracted (for example, physical principles of classical mechanical pulleys, levers, inclined planes not accounting for friction; a formula defining the speed of a freely falling body in a gravitational field in a vacuum; aerodynamics in its consideration pre-supposes and absolutely smooth aircraft wing surface and fuselage without microscopic unevenness.)

Mandelbrot intuitively reasoned that these deviations, mostly negligible and neglected, can sometimes by the mere coincidental culmination of many minor effects grow into a deciding factor, markedly and fundamentally influencing an unexpected direction of an observed manifestation (the so-called "butterfly effect"). Considering weather which changes and develops every second as a result of billions of practically endless minor physical effects dependent upon temperature, pressure, humidity, air, Earth and sea surface temperatures, sunshine intensity dependent upon the time of day and year, cloud

cover. Each of these individual effects has been "mapped" by classical physics. Each, in principle, is perfectly understood and is able to be calculated. However, this cannot actually cope with the quantitatively endless system of interplay and moment to moment changes in the sum of the effects. For this type of system, acting unpredictably as the result from the influence of uncountable minor effects, Chaos Theory has established the term "**anomalous attractors**". Today, classical models of illustration of so-called anomalous attractors commonly presented in literature are the double pendulum, dripping tap and Lorentz's water-wheel. Lorentz's example of hydrodynamic convection in a cup of hot coffee, displays the behavior of a flowing liquid or gas at the moment of the development of turbulence and the rise and development of warp in a waterway. The development of f sharph populations in f sharph ponds can likewise be considered a fine and vivid model example of anomalous attractors - with a supposition of a certain constant coefficient of population growth in a unit of time (for example - one year) with the simultaneous operational factor of the limited pond space and limited supply of food. The unpredictable behavior of anomalous attractors is absolute. In the presented example the development of the f sharph population can be expected as much as the possible standardization of some constant equilibrium position, as with the possible oscillation around that position. That oscillation can occur more regularly or absolutely irregularly if the amplitude of deviation or time interval of the deviation, the apparent regular course of oscillation can, after some cycles, acquire again a completely irregular course which develops at any moment. A collapse of the system as the result of a dramatic population growth and the resulting food shortage is not excluded.

It can be asked: Do we have the right to consider anomalous attractors, as well in connection with music? Before we attempt to answer this question, we must acquaint ourselves with some other further concepts in the Chaos Theory dictionary. These are bifurcation, entropy, phase space, initial conditions and the dependence of processes on them, randomness, homothetic dimension, non-linearity, indefiniteness, irresolvable models, stochastic models, stochastic process, instability, formlessness, renormalization group, dissipation, topological transformation, the abovementioned butterfly effect, separation, complexity and particularly fractals.

Fractals, respectively, a fractal structure (an object, organized) can be clearly imagined as a tree. Every branch is like a smaller copy of the whole (Mandelbrot: "...fractals are shapes in which - independent of the sense, which we give that word - a detail reproduces part and the part the whole"). Like a few branches grow from the trunk, as well, further branches grow from every on of those few individual branches. These branch off further and in the same manner continue endlessly. Another frequently presented example of fractal structures is a seacoast presented on a map, from an aerial view, from close-up and a very detailed view - the contour of the coast shows at different hierarchical levels the same manner of formation. Classical and very clear; simple examples of fractals are Koch's flakes, Cantor's dis-continuum, Sierpinsky's triangle, Sierpinsky's carpet. Contrarily, a very complicated fractal is Mandelbrot's aggregate. Mathematics in connection with fractals have developed a completely independent area of Geometry completely different

from classical Euclidean and the later (for example Lobačevsky) geometric concepts. Fractal characteristic research uses quite complex mathematic formulas (one interesting actual formula is the fact that circumference of a Koch flake - the respective curve is at the infinity level and that is when it is spread out to a surface a mere 10×10 cm in measurement). In our consideration of course it is not necessary to delve into such a detailed mathematical operation. Rather it regards understanding the principle of fractals and appreciating the reality that the structure of nature - considering all our surrounding realities - is in some manner fractal and it merely needs to be observed. Aside from the mentioned seacoast example it is possible to present many others: the shape and division of ferns, the structure of firs, bird feathers, leaves, the contour of the Earth's surface from minor unevenness to hilly terrain, mountain as well as alpine ranges, the plant kingdom from microscopic organisms to plants, bushes, from trees to trees of massive proportions, the macro-cosmos of space and it's miniature vision in the structure of the microcosm of mass particles, the internal structure of lungs, the interweaving of bronchiole, bronchial tube branches, bronchiole - up to the unusual amounts of microscopic cellule, distinguishable at the surface, measurable summarily in tens of km^2 (comparable to the circumference of a Koch flake)! Finally we come to the end. Fractal geometry gives a truer picture of reality than classical Euclidean geometry, portraying a simplified world perfectly lucid, right-angled etc., abstract from the (always!) rough surface of real objects (comparable with the above-mentioned "neglected" friction, air resistance etc. of classical physics, and as well, and Wittgenstein's statement below regarding "ice where resistance is missing"). Mandelbrot in connection with this speaks of an anti-Euclidean revolution in mathematics. For our consideration it will probably be useful to distinguish the so-called **self-conforming fractals**, occurring in a purely mathematical structure and marking reality that any part of a fractal at any hierarchical level is an exact copy of the original motif. About a **self-related fractal** occurring in nature, we can say that any segment or detail is very similar even completely identical with the original body.

Instability is a further frequent concept of chaos theory. Its result is the possibility of multiple mutually equivalent and at the same time contrarily continually developing systems at a particular time, respectively, situation of its course. We imagine a cylindrical rod subjected to a strong longitudinal pressure exactly at the axis. Theoretically, in a perfectly cylindrical shape with the pressure directed exactly at the axis, the cylinder would be able to resist the pressure or after exceeding a particular critical value it should begin to equally compress, that is, it should become shorter and thicker. From experience we know that the real development is different. The rod, in such conditions always deviates to the side under pressure and bends. The direction of bending from an endless multitude of possibilities cannot be predicted. Minute incalculable "negligible" factors rule this as a practical impossibility of orienting the pressure absolutely precisely in the place and direction of the axis and imperfect shape of the rod (the real existence of an absolutely linear rod, a perfect profile, absolutely perfectly homogeneous material is out of the question). These types of events in the course of the development of a dynamic system, when - in the result of instabilities of the system - one situation has two mutu-

ally digressive solutions, we name **bifurcation**. A determining factor, ruling further system behavior, at this moment become those "negligible" details from which classical (for example physical) consideration is abstracted.

Also, in the course of development of a dynamic system we can find features of fractal structures. The process does not take place - as we would expect - linearly according to previously planned "scenarios" of natural laws, formulated uncompromisingly by classic sciences, but rather as the consequence of continual potential vagueness. This is instability, whose course incessantly - in individually occurring bifurcating situations - branches out into two, four, eight... possible varying solutions. Fractals do not only develop as was described above, statically rather in the course of time that is dynamically and kinematically.

Entropy - this idea, known also from information and probability theory - is a quantity expressing a measure of indefiniteness. We imagine dropping a porcelain pot onto the floor and all that remains is a collection of shards. Is it possible to predict that in dropping that collection of shards onto the floor they will again form the original pot? No! The presented example is a practical clear exhibit and confirmation of common knowledge resulting in the so-called **second thermo-dynamic law**: everything, left to itself tends from order to disorder (from organization to chaos, from information to entropy), and not the opposite. The state of the "collection of shards" in our example represented a true state of a high value of entropy. That is a high measure of indefiniteness in ordered elements of a mass. In connection with considering entropy it is possible to propose the following problem; if we pour a glass of ink into vessel with water we cannot expect that the water and ink will remain strictly separated. The molecules of both fluids begin to gradually mix. The water begins to darken and the ink to thin. The entire process of mixing will be the growth of entropy. We can ask the question: Can the final state of completed mixing - that is, the highest entropic value state when in each mm^3 of the mixture will contain the same mutually proportional numbers of water and ink - be a true state of the highest measure of indefiniteness? Or another example: Can a forest be considered as unordered in whose space trees are placed altogether uniformly? It still forms a structure in which we can state a certain form of order though it wasn't planted in rows in a regularly measured distance (as would be a hedge for example), rather it formed spontaneously resulting from completely free movement of flying seeds. Can this structure be regarded as indefinite, that is unordered? It seems that the nearest truth will be the stand-point that it is order of another type. The essence of that order is however apparent if we do not take into account a study of the movement of each individual seed flying in the wind, rather observing the behavior of the system as a whole from a distance and in the long term. This example, as it were, confirms the initial thesis that chaos is a definite form of order and at the same time shows a way of understanding the system of chaos. (We can think of a number of considerations, confirming the wisdom of folk sayings in which intuition, experience and observation capabilities and the ability to understand hidden and visible tendencies play a key role and is displayed in an observed system as in the example of weather.)

At the moment of bifurcation, that is the moment of characterized uncertainty the unpredictability of the following system development in the resulting two or multiple possibilities of various results of the current system are characterized as well as spatial or temporal boundaries between the two or among the potential or actual possibilities (the pressed rod will begin to bend at a particular moment whether to the left or the right, a ball placed on an unstable surface, at the peak of a concave surface - will begin to move in one or another direction from a concrete point - boundary - located at the peak). We can also register the boundary in the course of a dynamic process during a behavioral change at a concrete point in time. (In the study of turbulence we are interested in what happens in the system at the time of liquid acceleration at the moment of change in the steady flow in a turbulent or at the time-point bordering two qualitatively differing manners of behavior of a system.)

A further representation of chaos theory would lead to overindulgent growth of this text. The presented examples are illustrations and demonstrations of our opinion that chaos theory is not without connection to music, respectively music theory which will suffice for now. We will now turn our attention to our own music dilemma.

Music theory and its subject matter, earlier and today

Music theory by the manner of approach to its subject matter or own research, genesis and development does not differ from classical sciences. One of its ambitions from the beginning was always an effort to augment the systematic approach of music structure and music expression research, from merely a list of music phenomena to its, if possible, more exact understanding and formulation of common rules. This tendency is visible among ancient thinkers (Pythagoras, Aristoxenos) and continues through the Middle-Ages, Renaissance and Baroque (Boëthius, Quido of Arezza, Glareanus, Zarlino, Rameau, Fux) up to Modern music theory (Riemann, Kurth, Gevaërt, Hauer). Particularly, in the areas of traditional disciplines, they devoted themselves to one facet of tone height, tuning, tone systems to the more recent period - to questions of harmony and other facets of compositional technology principles - in the previous century particularly in questions of polyphony, basso continuo and also tonal harmony, in the 20th century further structural disciplines, some very rationally and exactly elaborated which will be written about later in this text. It is necessary here to emphasize that music theory as we traditionally understand this concept, arose and developed first and foremost in European environs, in its particular semblance, within its internal divisions into the presented disciplines, its working methods, etc. All this corresponded to the particular semblances, character and needs of its matter, that being European music.

Efforts were made in areas of compositional structure and interpretation in the struggle towards an esthetic ideal of European Classical music and the ideal form. There is no dispute over how in an analytical regard, when merely listening to Bach's *The Art of Fugue*, it is impossible not to wonder at the marvelous and incomparable sense of order

exhibited as a whole as well as in each detail of the work and the rich meshing of its internally organized relationships. Along with the compositional technology, this work is a display of "higher mathematics" of the composer's work. Similar homage can be paid to Mozart's, Beethoven's and Brahm's works. It is not possible to wonder at music theory, face to face with its conformant compositional achievement and the resulting analytical target which endeavors to its own more thoroughly refined working method, taxonomy and terminology - particularly in regards to extending attention to logical connections and exact thought and, as well, precise formulation of conclusions. Joining this activity is also work in music acoustics (from Tartini, Helmholtz to the exceptionally rich possibilities of modern sound labs), the physical discipline. In regard to the reference to rationalistic concepts of 18th century thinkers we cannot omit the significant input of philosophers and mathematicians such as R. Descartes, M. Mersenne, L. Euler from the discussion in determining the form and direction of music theory, by works which directly contributed to the resolution, in its time, of dominant music theory issues, issues of scientific harmony and this fact, among others bears witness to the pertinence of music theory to the family of classic disciplines which awaited the "crisis of science." The 20th century alone found many composers (frequently - but not only then - in a sequence of creative steps of the Second Vienna School, particularly A. Webern) in an unprecedented extension of compositional advancements accentuating rational to the mathematically exact approach to the organization of all music material (P. Boulez, K. H. Stockhausen, I. Xenakis). In this situation music theory again did not intend to remain in the background - and again - face to face with reality of a circumscribed approach, a number of composers in their own compositions, otherwise true to their traditions, made efforts (and continue to do so) towards a further perfection of their taxonomy and analytic methods valid according to the new mathematical and mathematically related working advances (the theory of probability, aggregate theory, information theory, game theory, succession theory, modern statistics, cybernetics). In this moment it is ripening - hand in hand with its sisters, European classical sciences - to the abovementioned "crisis point" at which all were found at the end of the 20th century. As is shown, here all earlier exactly formulated principles exploited by efforts of the previous generation have been implemented. How?

Stravinsky in response to R. Craft's question regarding his auditory appreciation of serially composed music said: "We hear much more in the harmony of those compositions, harmonics according to an atonal system. I, today, for example, hear tonally the whole first phrase of Weber's Symphony (not only that famous place at *c minor*) and melodically everyone today hears it more tonally than 20 years ago." This response, in a nutshell, testifies a lot, among others as well what Stravinsky (and we with him) envisaged as tonality (that is the membership of music to a defined key, generally - to a tonal center) and not as something fixedly given, objective, existing in music independently of the subjectivity of the listener, rather the opposite - on behalf of the listeners subjective interpretation, his **interpretation of auditory perception**, bearing certain information consisting of sensor perceived forms of sounds themselves as well as structural relationships between sounds and sound complexes sounding simultaneously and sequentially. We identify with

Stravinsky's point of view because we understand perception (and not only musical!) as an active process: whether it is very simple to understand perception as a mere "registration" of that which our senses inform us of (as some kind of notional "cloth" on which the perceived reality is only "projected"). The perceived subject **always** from the whole separates **for itself** fundamentally at the expense of the non-fundamental, the marked at the expense of the unmarked, conspicuous at the expense of the inconspicuous, and the attention is concentrated on what is separated; the remaining perceived as background (in place of the imaginary "cloth" it is possible in the process of perception to see some kind of "playground", "ring" in which individually attacking sensations and the information carried with them mutually compete, in passing, for our attention. We, ourselves, are, in all this, the "referee" and "spectator" at once). The appropriate skepticism, into which we may sink to at notions, that everything is then only a matter of the arbitrariness of subjective interpretation and therefore absolutely ungrounded. It is possible face arguments about limits in which the arbitrariness of our interpretation corresponds to the objective appearance of perceived reality. On the question regarding the shape of billiard balls, balls, globes and other similar articles, the response, undoubtedly to all questions will be that it regards, unambiguously, a sphere. Not completely certain is that type of answer in the case of a question regarding the shape of an apple, crown of a tree, a round cloud; the shape of this type of object can be but needn't be interpreted as a sphere; everyone knows that an apple cannot be a real sphere, nor the crown of a tree: after all it is made up of close-knit branches, leaves..., a cloud is actually formless, it has no sharp contours. The perceived object can be, but needn't be interpolated into such items as spheres. To repeat - **the perception of these objects can but needn't be interpreted as a spherical shape**. It is apparent that the possibility of unambiguousness or ambiguousness of an interpretation of the perception of a concrete object can - case by case - differ.

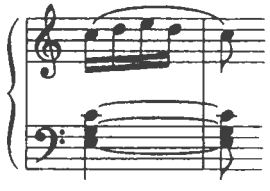
Taken strictly logically there is no difference between billiard ball, a ball and a globe on one side and an apple, a tree crown and a cloud on the other: none of these objects in reality are truly spherical. A perfect sphere can exist only in our imagination. However from our perception viewpoint the difference between the first and second group is obvious: whereas a billiard ball, a ball and a globe **must** be perceived as a spheres, the objects of the second group - apple, tree crown, cloud **can - but needn't** - be so perceived: We can imagine them as something different: from the standpoint of analyzing perception they are **ambiguous, ambivalent**. In the case of perceiving music it is not different: whereas the sequence of harmonic function (cadence) T - S - D - T **must** be perceived as an unambiguous expression of particular tones, in the cited case of Weber's Symphony No. # 21, the initial ascending major sixth A - F sharp **must - but needn't** - be upon hearing perceived (independent of the fact of the use of the exact 12-tone composition method) as a burst - albeit fragmentary - of *D major*. **The initial melodic formula is therefore** (similar to the images of the apple, tree crown, cloud) **tonally harmonic ambiguous, ambivalent**. We ask: Does the presented example not resemble something from chaos theory? We recall the concepts of "instability", "bifurcation" and "separation"...

It is necessary to note the fact that harmonic ambivalence is not (as it may have seemed in the presented example) peculiar only to atonal music; it can be found in examples of strictly tonal music. It is possible to imagine that the more complicated harmonic music structure is and the more extensively ingrained cadence marked in tones are (for example in the case of music by Brahms, Wagner, Debussy, Skriabin), then the greater the probability of the presence of harmonic ambivalence, therefore ambiguity of tonally harmonic interpretation, we can expect. (We are dealing with solely ambivalent harmonics; it must be mentioned here the idea of tectonic ambivalence - as in the excellent observation of Jaroslav Volek, formulated in the study *Tectonic ambivalence in the Sonata Form of the Symphonic Movements of J. Brahms and A. Dvořak.* We note that Volek devoted himself to the exact same phenomenon - that is - the dual possibilities of subjective interpretation, ambiguity of aural interpretation in kind of an objective phenomenon - in that case the construction of a music whole, musical form and furthermore a classical form.)

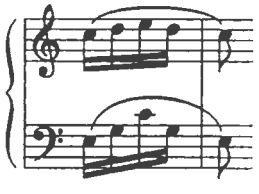
There was mention of a higher probability of the occurrence of harmonic ambivalence in the case of a more complicated harmonic structure, a rather more extensively in-grained cadence marking of tones. However harmonic phenomenon, also, at first sight seemingly unproblematic can provide, at more detailed examination, many surprises. From examples we can find many. We have selected a few.

In studies of harmony - as well as in scholarly discussions - vary opinions on the function of classification of so-called the intoned inverted fifth chord (suspended inverted fifth chord - for example *g c e,* conveyed to the dominant function - *g h d).* According to traditional interpretation, emanating from basso-continuo use, it concerns the dominant, enhanced by the double suspended (suspended tones do not divide the harmony of the given chord). Current studies, accounting for empirical practice with the latest music, basso-continuo use deviating from the original, provide many advantages to the concrete sounding tonal chord structure and interpret the inverted third chord as tonic. Both arguments have logical arguments. However, the question is another: **What do we actually hear at that given moment**? Furthermore we may ask: What, in this situation, do we actually hear if we meet it in the context of the music style (musical expression) of W. A. Mozart, and again in the context of the style (musical expression) of L. Janáček? And finally, as in the case of L. Janáček, is the given practice, in the context of his musical expression, intentional (or merely subconsciously) archaistic? From the given example can be seen that the written "rules" of the study of harmony are very simple, linear, logical but however real live auditory practice and experience is infinitely richer in its hyperfine nuances to ultimately unattainable by those rules. What does all this recall? The problem of meteorology with the infinitely complex dynamic system of weather? The influence of the negligible effects, such as frictional resistance of air? We ask: Dare we look for in music, more exactly said - in music thought (encompassing everything from a musical idea to it realization to the auditory perception of the sounding music) - a dynamic system which would fall into the category "anomalous attractors"?

As another example, again on the theme of "melodic tones" we present a simple melodic formula in *C major* in 16th note progression at a quick tempo, based on an underlying tonic inverted third chord:



In this example the *d* tone is aurally perceived and unambiguously analytically interpreted as a clear tone, not participating at all in the harmony of the given location. The entire passage will be stated in the key of *C major* will be perceived as the unchanging tonic harmony. We imagine again this accompanying **sextinverted fifth chord** in the figurative stylization, moving syrrhythmically with the movement of the presented melodic voice (the aforementioned stylization form will be compared in the first example by one change):



As the presented stylization change ("Albert bass") didn't have, to present according to all the experience or theoretic prerequisites, a harmonic change versus the first version, the auditory impression will be essentially different. In the result in the given concrete constellation, regarding the temporal concurrence of both figures, it occurs in this case - albeit coincidentally - to the rise of very prominent in classicism and often frequented, conventionalized progression of the so-called "French horn fifth", which to us will most probably - despite the quick sixteenth note movement - suggest the dominant interpretation of tone d. The harmonic weigh of the tone *d* in spite of all experience and theoretic prerequisites markedly grows. Why do we present this example? It serves as an illustration that the incidental culmination of a few trivial causes (the feasibly melodic occurrence, thus for harmony an insignificant tone, a negligible stylization change of the accompanying chord, rhythmic interplay of both voices, the concrete environment creating a conventionalized sequence of incidentally arising diapason form) results into a marked unexpected qualitative change in regards to the actually heard harmonic-functional capacity of the given location. Does not this type of example recall something which "anomalous attractors" characterize? Is this the unexpected growth of the sense of some

minor seemingly negligible causes as the result of their coincidental culmination? Do we not come upon here the "butterfly effect" in music?

In the context of the given example we can mention Schönberg's idea formulated in *Harmonielehre* - that there do not exist non-chordal tones, that each tone which is heard in music in some manner projects a harmonic event - idea, frequently interpreted and commented upon as one of many possible demonstrations of the author's proverbial eccentricities. But yet: Isn't there in a such seemingly „bizarre" standpoint, partiality, perhaps not quite consciously, but nevertheless with impeccable intuition, a hyperfine encoded sense of understanding the above circumscribed ponderously comprehensible, but the nevertheless present and functioning influence of those at first sight „negligible", but in end-result subsequently decisive causes? If we would like to still further in more detail comment on the glance at the fragment example, we could add: that which Schönberg could have in mind, doesn't necessarily mean that every tone is a bearer of harmonic function. It can however - to perceptive readers - infer as much, that between both qualitatively distinct categories of classical harmonic-analytical scorings of individual tones (chordal - non-chordal) there is no sharp border, rather connected continuous transition, so continuous a scale of infinitely finely differentiated number of possibilities, found somewhere in the "medial space" between the mentioned poles, the possibility of its hyperfine differentiation by the classical method is more or less difficult to notice, as is in field of meteorology the applied knowledge of classical physical laws are difficult to notice in the sum of factors, participating in the development of weather. Doesn't all this remind us, for example, of the statement above in connection with Benoit Mandelbrot and his realization of the endless quantity of endlessly small and so classically physically unmappable physical causes of the continual and dynamic development of weather? Does this not show possibly that a harmonic phrase has all the attributes of the anomalous attractors? It is apparent doubtlessly that in this viewpoint that the traditionally applied classically harmonic-functional interpretation of a musical manifestation is markedly black and white; by that of course it does not mean to say it is worthless! We are here merely discussing the stated need to uncover further, until now, unused possible viewpoints of harmonic manifestations, and so - important developments in the analytical and systematic theory of harmony. For us as musicians it is not completely without its interesting points, which Schönberg published in his *Harmonielehre* in 1911, thus 13 years prior to Mandelbrot's birth and more than a half-century before the birth of chaos theory! Only marginally do we mention here that a similar opinion by F. Z. Skuherský, expressed in the introduction to his *Study of Harmony* as early as 1885, the essence of the practical part of the work does not stray from the traditional idea of harmony of the era as a study of the construction and joining of chords.

We'll spend another moment with Schönberg. We will try to analyze his idea of the twelve-tone composing method - dodecaphony - on the background of chaos theory. We recall above in reference to the interpretation of the idea of "entropy" described in the example of a tree in a forest, growing from a seed, strewn completely coincidentally and yet in a particular sense orderly (chaos = another form of organization). As stated

before, this does not regard an artificial organization planted regularly over a wide-spread "living enclosure". Is it not possible to perceive on this type of intellectual background, Shönberg's method as an intensive search for the key to understanding that type of "order of nature", respectively for its simulation or even better - for the **artificial application of his principle** in composition work, as a sure display of support for the structure of geometrically regular, symmetric, right-angled, Euclidean unambiguously definable, and conversely, as a display of admiration of which Mandelbrot called the "geometry of nature", as a method of its imitation in the creation of music structure? (An example of subconscious, intuitive understanding of this idea which Schönberg himself provided with a rational method was Wagner and his method of developing the musical idea in *Tristan.)* Does this not perhaps offer the proposed question of music theory more attention in the face of the phenomenon of information and entropy, respectively organization and disorganization - as a principle, functioning and notable in the organization of musical structure at all? Does not that attempt of a historical advance in the composition process initiated by Wagner and completed by Schönberg, present not completely similar to that above described case of mixing water and ink, when the final status of completed mixing (removing the barriers between both mixed fluids, comparing the amount of molecules in each mm^2) that it is possible in a certain sense to analyze as the **achieved maximal measure of entropy (disorganization),** and of course at the same time in another sense - as an **achieved system of another type ("system of nature")**?

It is true that in the idea of information and entropy operate some directives of compositional practice of the second half of the 20th century and with it the related music theory considerations - particularly regarding the valid stochastic method of composition (whose connection to Schönberg, whether direct or mediated, is undeniable). Here it will be so noted that, though it is undoubtedly sure for us an attractive argument which we could use for confirming our own reasoning, **though we have in mind something other**: it does not regard the application the idea of entropy and information in the framework of an instruction, recipe, "cookbook" how to compose, but rather about its orientation to the methodology of music theory in general, about its projection into its "philosophy" alone. We come from a deep conviction that all music, not only that according to Schönberg, but also that prior to him, around him, in Europe and outside of it, is subject, in one way or another, to those principles, which have found their expression in Chaos Theory. That all the above is then valid for choral music: Josquin's, Bach's, Mozart's, Beethoven's, Brahm's, Wagner's, Mahler's, Hindemith's, Stravinsky's, Bartók's, Shostakovich's, Lutosl'awsky's, Messiaen's, Ligetti's, and many more composers, but also for folk music, ethnic, artificial and non-artificial - briefly - for any type of music manifestation.

The above declared remark about the natural support for the geometrically regular, right-angled etc. structure may inspire us to an independent consideration of the context in focusing attention on rhythmic events in the framework of a live music manifestation. While the classic European score (and at the same time inseparable from the traditional European concepts of rhythm) suffices with a few rhythmic values mutually divisible into simple arithmetic values, in a real, live music manifestation they are never mutually tempo-

ral dimensions precisely realized. The measure of deviation - judged case-by-case - differs, from values quite insignificant-imperceptible, as is in a significant percent of European classical music to evidently obvious values of observable deviation from a steady periodic pulsation in the case of jazz, ethnic and folklore music and much music from the second half of the 20th century, but also - in the case of European classical music - in the rhythmic course of instrumental concert cadences, in the case the most diversified agog deviation, or also a nice example of a proper authentic interpretation of a Strauss waltz in a performance of the Vienna Philharmonic, during which it is necessary that the second beat be slightly extended, respectively a minor rhythmic shift is slightly "weighted", and not just any but in the qualitative sense **quite specific**, no less quantitative **immeasurable** manner. Similarly as in the case of the jazz off-beat, here also, "we feel only that way is it '**it**' ". An exact score however is not possible; here apparently something essentially escapes our rational control. In all these examples not only does the exact distances of rhythmic measurements play a role, as we are accustomed to considering in the spirit of the good morals of classical European music theory, rather the interplay of several factors (again!), among which are not only those ideal distance proportions, indicated in writing, but also the significance of each individual rhythmic impulse (here we again note the significance that the dualism of classical "heavy" and "light" periods is again a very roughly simplified real characteristic and fundamental entity, requiring endlessly finer differentiated space between those two fields). Furthermore the meaning and musical sense of each of concrete rhythmical impulse derived from context impulse of others plays its role, from the context of melodic, harmonic, dynamic, and from concrete factors, from origin of its rise (beat, stroke, breath, vocal manifestation...), from partial "extra-musical" components - body movement, the rhythmical structure words in the event of vocalic manifestation, etc. All of these influences appear diversely at the level of different tempos, not to speak of the diverse possible requirements of varying styles and genres. The above presented example of the prolonged second period in a Viennese waltz does not necessarily need to be applied to the waltz in Prokofiev's "Cinderella", and is impertinent to other three-beat dances - the mazurka, the polonaise, the minuet.

At a qualitative and quantitative defocusing, billowing, loosening, patterning of the rhythmic pulse of a particular live music performance, in pursuit of the extremely pure mechanical rhythmic pulses of computer simulated music, all the above mentioned various factors take part in mutual combination and in the most varied fashions. Again, it is possible to ask: Does this not remind us - again and again - of the butterfly effect, of the development and changes of weather, of anomalous attractors?

As is evident, in spite of the great tradition and robust prevalence of European music theoretical thought, our actual theoretic knowledge of the phenomenon *music, music structure, music thought* embodies very many unknowns. It seems that there is still a lot about music which we do not know. For music theory, music is an object of observation, as is the human body for anatomy or minerals for mineralogy. Music theory perceives music as something given, measurable, prepared for analysis and description in its objective form and simple function, creating itself as black and white, unambiguous, in principle,

scheme and standard, neither too aspiring to encompass that, which music - as a display of human intelligence, imagination and creativity, and at the same time a specific means of communication - in reality is (must be!), that is - **a non-linear dynamic system**. Music theory otherwise speaks for example about the principle of contrast and identity, about the principle of recurrence, internal elements and others but does not propose any further questions about the roots of the stated principle, nor considers that, which with its apparently wholly undisputed function does to other approaches - be it causally contingent, logically interpretable, an intentional or completely accidental factor in the moment of the compositional process, music interpretation and listening.

About fractals in music

We now pose a further question which can be inspired by chaos theory: Do music, music thought, and music discourse embody features of fractal organization or not? With complete trust we declare: Unequivocally, yes and that in even in several various aspects.

We spoke of self-related (that is at all levels very similar if not completely identical) natural fractal structure contours of the relief of the earth's surface from minute unevenness to hilly terrain, mountains to alpine ranges. We imagine the constructed arch of Beethoven's sonata movement and its folds. The arch and fold of every one of its individual parts, every theme, individual phrase at the two-measure level, measure etc., to minor melodic ornaments, even every individual tone at a microscopic regard offers the possibility to observe the ascending phase, chiming and subsequent fading. We cannot though not consider that at the most varying hierarchical levels the same takes place! Does this not remind us of that stated theory of chaos many times over presented example of scrutiny of the contours of a seacoast at different distances - from an aerial perspective to in the immediate vicinity?

In another analytical "section": Does not the tonal design of the classical sonata cycle (that is the course and mutual relationship of the keys of the individual cycle movements), the tonal design of every individual movement (the course and mutual relationship of the key within the movement) shape, analogical course of harmonic functions in whatever place in the music flow (at all designated hierarchical levels we can find identical harmonic-functional systems, given by varied, and always anew by that functional relationship to the center - the tonic)? As well, what is possible to observe at the superior and medial hierarchical levels (that is the macro- and medial-structure levels) of a harmonic event would be possible to observe as well at the subordinate hierarchical levels, at the micro-structural level, that is, in the area of melodic tones where we are not commonly accustomed to analyzing events as harmonic-functioning, where no-less it ensues from the previous consideration (Schönberg, Skuherský) to a certain form of harmonic functional events in attendance as well. As a concrete example we may use the first Movement of Mozart's *Sonata in C major for Piano*, whose tonal system (C major - G major - F ma-

jor - C major) in the area of macro-structure applies in its sensible sequence every function of harmonic cadence, applied as well in the course of both themes of the movement and identifiable simultaneously also in the microstructure of the melodic event.

Another argument for the fractal interpretation of tonal-harmonic structure can be the fact regarding the rich frequency possibilities (temporal density) of alternating harmonic functions in varying types and styles of a musical manifestation. From only the function falling on the space of several measures to a very driving sequence of alternating functions - for example after each eighth - see Brahms' Variation XX from *Variations and Fugues on a Theme by Händel.* From the possible various frequencies of alternating harmonic functions (various momentums of harmonic rhythm) comes as well the possible observable (audible) kind of harmonic event process at various hierarchical levels of the music form. We imagine then - in the framework of the further development of that consideration - music, applying a harmonic dwell (for example a dominant dwell, preparing the final rendering of the sonata movements of many of Mozart's or Beethoven's symphonies, Bach's Preludes and others) in a very rich and, in the temporal course, dense harmonic event. We are offered at least two possible harmonic interpretations of that type of display, the common manner of harmonic analysis devotes it attention to the event over the dwell and the dwell itself "removing from the game" with a reference to the fact that it regards a dwelling, that is non-chordal, in its own harmonic event with a non-participatory tone. In the second interpretation it is possible to permit a different idea, accounting as well for the undisputed reality that the dominant, represented by the dwell, sounding frequently and markedly over a temporally extensive surface, presents a significant harmonic-tectonic preparation of the final, calming and closing tonic. There is no dispute that the longer temporal space expanded by the dominant function gravitating harmonically to the delivery of the closing tonic, and during its entire duration, and above which develop events in relationship to it appear as ornamental and otherwise factually and kinetically enriching, however non-chordal, does not take part in the given dominant harmony. To the question, which of these two interpretations matches the actual aurally described phenomenon, the unequivocal answer is: both. Both levels of the harmonic-functional event are perceived at the same time in their full value; merely this manner of listening enables the perceiving subject a full grasp of the musical sense presented in the music structure. There is no dispute that this type of structure displays features of the self-related fractal and we perceive it as such.

Another further analytical "section" enables a glimpse of the fractal order of music structure in its kinetic that is, meter-rhythmic organization. Again the same reveals itself to us: hierarchy, organizing fundamental metric shape - measure (alternating light and heavy periods), many analogically observable at higher hierarchical levels existing (two-measure alternating "light and heavy measures", alternating periods "heavy and light semi-phrases", alternating forms "heavy and light parts") and at the lower hierarchical levels (for example, the internal divisions of counted periods in minute rhythmic values - eights, sixteenths, thirty-seconds - display a microscopic form of order of the analogical organization of that section).

Not presented are convincing corroborating examples of the fractal character of music structure, classifiable along side the above named examples - a seacoast, a fern, a tree, bird feather, leaf, and earth relief? Is that not perhaps also confirmation, respectively by another manner of expressing fractal structure of the tonally conceived music's whole picture, presenting itself to us in the application of Schenker's analytic method, disclosing to us a glance into that structure as if from different distances? (Comparable to the above mentioned views of the contour of a seacoast!) Does this not, as well, in a certain manner in regards to the fractal character of a musical whole in Risinger's thought of centric hierarchy, envisage a musical structure as a imaginary "tree", from whose sole trunk (centre) grow several branches, further again several fold branching out? Both perspectives, though their authors never in text used the expression fractal, de facto the fractal character of a music structure - each in their own way - reveal, confirm and apply it in their analysis, disclosing a striking relationship between individual hierarchical levels and regarding the mutual interplay of various elements of musical expression.

In final consideration of the fractal order of a music structure, we present some examples of the occurrence of the theory of self-conformity fractals (these fractals, as was stated, would be difficult to find in nature, they are known from mathematics: displaying at various hierarchical levels consistent order). These are examples of music structure, applied in practice with multi-stage diminutions or augmentations of music (most frequently thematic) material. True precise diminutions and augmentations enable the achievement of fractal self-conformity. Just a cursory look at Fugue No. 7 from Bach's *The Art of Fugue* which applying diminution and augmentation of the theme at the same time with its basic rhythmic shape - simultaneously and in succession - enables the realization of precise fractal self-conformity at three hierarchical levels of the structure. Kabeláč's symphonic passacaglia *Mystery of Time* develops in a similar manner a broader expanse in the spectrum of possibilities.

It is possible to state that while the examples of fractal self-relationship testify to the fractal character of music in general, the presented examples of fractal self-conformity (Bach, Kabeláč) are moreover revealing proof of conscious compositional intentions, the composer quite consciously and purposefully created a structure of those characteristics which we can observe in a fern, a leaf, a spruce. This undoubtedly testifies, not only to their genius in music inventiveness (there is no need to illustrate), but - what interests us particularly here - is their exceptional intuitive perception of the fractal nature of the world in general. Again we can state - Kabeláč who was Mandelbrot's generational contemporary can easily be, in this context, named in the same breath with the above named pioneers of chaos theory; Lorentz, Smal, Prigogine and others. In the case of Bach and other "Polyphonics" that intuition was exhibited 250 years earlier! The presented masters, of course, are not the only possible examples of the referenced intuition. It is possible to mention Janáček's prosody as fractionally diminution derivations of the motival-thematical material of his compositions. Weber's privileged series (particularly - but not solely - the famous example from Op. 24!), divided into fractions - halves, thirds, fourths or sixths, display among themselves the same characteristics and relationships

as the series itself displays in its surroundings. The intuition for the fractal order of the world doubtlessly projects into the "atomic" structure of Weber's creative works in general (including compositions of the pre-dodecaphonic era). We can, furthermore, mention the structure of Messiaen's modes, internally divided into halves, thirds, fourths and sixths according to the organized segments - sorts of modes in modes, and his rhythmic working with diminution in complex mutual dimensions of individually simultaneously progressing sections. Overt fractal "feasts" are presented by the second movement (*Arietta*) of Beethoven's *Sonata for Piano in C minor op. 111*, presenting in the course and building of the theme and individual diminution variations of the original key rhythmic model sequentially in ratios of 1:2, 1:4 and 1:8. A nice fractal "confection" was prepared for us by B. Bartók in the initial movement of *Music for Strings, Percussion and Celeste*, whose closing recapitulation of the thematic material (see cca the final 3 measures) in its melodic contour, arising from the central tone *a*, culminating in the three-tonal remote *E flat* and again returning and resolving to the initial *a*, including the mirroring counter-movement of the participant voice, presents a diminutive, "microscopic" form of the constructed course of the whole movement. (In the case of the construction of the whole movement the mentioned mirroring counter-movement of the movement was realized by the growing sound contour and density of the music course by a sequence of ascending fugal polyphonic voices symmetrically in both directions from the initial central tone of the movement *a*, and that process continued to the achievement of a tectonic climax of the movement upon the tone *es* and finally returning to the initial central *a*.) The described exhibit was once remarked as more or less a composer's game which when heard no one recognized in the same way. It isn't so. In reality they are perceptible and perceived, of course, differently, subconsciously. We know of them even when we are not concretely informed.

A rich overview of the fractal structure of music is interesting in itself. For us however, this experience is but the entryway to a deeper understanding of the unknown or perhaps the notional, to that category of apparently negligible minor sources of music theory largely judged facts of influence of fine differences of a music manifestation, hearing, perception, experience dependent upon individual music experience, temperaments, imagination, fantasy, vision, memory, observation, capabilities, finely differentiated and other characteristics and capabilities of the perceiving subject (see the note above regarding our psyche as a "projection screen" and "boxing ring"). The hierarchical level upon which one perceiver fixes their attention as fundamental can - in certain environments, for example, in the case of minor tempo changes, in the laying out of the interpretational emphasis on some elements of the music and the like - to other perceivers seem as subordinated or the opposite - super-ordinate.

Each listener can, in perceiving the structure, find a slightly different (obviously - not completely different) musical sense. Only for comparison, we present the following - as well "fractal" - model situation: a stem of grass, upon which we can tread, can to a beetle seem as the trunk would seem to us, under which we could hide. A single-celled microbe would perceive that stem of grass as something permanent and stable as a tall cliff upon

which we could build a lookout tower would appear to us. A discarded cigarette stub would appear as a blaze, for the microbe it could mean a natural catastrophe like the eruption of a volcano. By banal simple examples we illustrate the possibility of differing perceptions of the same real fractal order of reality (structure) at the individual disposition of the perceiver in focusing on certain items on one of its concrete hierarchical levels. To be completely concrete in relationship to our consideration of music, we present an example of two conductors of whom one chooses a beat scheme with pulsations on three, on four, on each beat of the measure. The second directs the same music in the "una batutta" manner therefore focusing on another hierarchical level of the meter-rhythmic structure of the music. Undoubtedly we agree upon the fact that the **musical significance** of both conductors' gestures is not identical and the presented difference by some manner projects to the final result of the sounding music.

Regarding the ideal form and rules

For considerations devoted to the fractal character of a music structure we turn our attention to that which - in the context of European music - is characterized as "the struggle for the ideal form." What is the *ideal form*, actually? In geometry it can be a sphere, a cube, an equilateral triangle, the elegant formulation of the Pythagorean theory. How to understand this idea in the context of music? Taken strictly - if we envisage music positivistically as an objective sound fact then perhaps our requirement for the "ideal form" would be returned by most probably a constant unchanging sound of aliquot polytonal - harmonically entirely harmonious, undisturbed not by its own sound or change in the course of time. We very well feel that this answer is dissatisfactory and isn't what we are looking for. That which we are looking for is perfection, respectively authenticity, in a processional sound structure, temporally alterable, in its sensibility perceived and appreciated. It is connected actually with **the experience in time of an underway process of changes perceived sounds and its musical sense**. Insufficient in that: that *something*, which we are considering, distinguished by some "logic". When listening to music **we recognize movement**, and regarding composition we hear it for the first time. If heard in some places - if by mistake or intentionally - something which "doesn't belong" there, our sense registers it - similarly for example as a flaw in a fabric, a forcible encroachment into a region, a mis-chosen word form in a sentence. Could it be an expression of **true logic** in the case of an address, which isn't a verbal address?

We consider a further question: If we imagine Michelangelo's *David* as an *ideal form* in artistic manifestation, are not *The Venus Torso* or one of the large heads on Easter Island creations in a certain sense also ideal? In the core of all these manifestations wherein lies the common ideal form? For this we have that it is apparent first of all the undoubted authenticity of each, sensory perception and psychologically identifiable form and material consistency and integrity, corporeal ideal, that is, the fact that it is not merely a block, emerging as a result of a random constellation of material parts, rather a specific product

of invention, intuition, fantasy, creativity and will of a human. This for us regards in the questioning of the idea content of the *ideal form*, more deeply than its idea merely in the sense of the professional mastery of the "rules of the trade" - even when it is of course that as well! It is necessary here to state that the main focus of classical European music doctrine, respectively, the technical music composition theory, was traditionally focused on finding and formulating those rules of the trade, providing **methodic instructions with the goal of developing capabilities** to create "the ideal music form". As is shown, the connection to that tradition appears in the present situation of the "postmodern breaking of bread" as a dead-end, and by attempting to supplement the "old good recipe" of classic harmony, polyphony, of music forms and further disciplines apparently by revolutionarily innovative compositional instructions (today some might say "compositional manual", instructing in the operation type a combination, interpolation, applied steps and resulting theory of probabilities, aggregates, progressions, games, information, working with statistic systems). **Searching for research possibilities for *real* foundations of the ideal form, that of those sensorially perceptible and psychologically identifiable form and material consistence and integrity of musical manifestations however - in the light of the central thought of this study - can seem like an exigent provocation of music theory and as a possible perspective of further avenues of its development and sensible direction.**

Let's return again to the question posed above in the consideration of the "logic" of a music manifestation. We ask: Does music expression follow any rules? Does it have its own "grammar", "syntax" or "vocabulary"? If so, what are the rules? Who determines them and who knows them? How does each individual "user" master the expression? Musical expression is developing. Various musical languages mutually influence each other - changing the "rules". Do rules exist or in those changes to musical expression do the changes not apply and the "rules" remain unchanged and are unchangeable?

A similar question was posed by Ludwig Wittgenstein in the context of researching the structure of a language and the answer found was in the idea of the **foundation and function of a language as a game**. He considered the following: "We think only on that in which case we speak. Some type of game is being played according to certain rules. The Rules can be an aid in learning proper play. One studies and becomes familiar with and practices it in its use or is part of the game itself. Or: Certain rules are not used during learning, during play itself nor are fixed in some type of list of rules. **A person learns the game by watching how others play**. We say, however, that it is played according to this and this rule because **some observer can infer those rules from the practice of that game**, as a type of natural law by which the game interactions are directed. **How does the observer distinguish, in that case, between player mistakes and the game interactions**? Therefore there are certain indicators in the behavior of players. Think of the characteristic behavior of the one who self-corrects in some slip of the tongue. **It is recognized that this is done even when we don't understand the words**." (highlighting by this author).

In the above citation from Wittgenstein's *Philosophical Research* much is said about language, and we are finding, that similarly, if not correspondingly, it is possible to say the same about music. How would it be possible to regard those **real rules of music expression**

in the light of chaos theory? The principles of classical harmony, formulated by classic music theory, apply, as it seems as some type of musical "grammar" and "syntax" of music thought of the tonal era, roughly up to 1900. Music theory described sequentially was felt as obligatory. Music theory literature, intended for compositional practice, is formulated as obligatory bans or directives, inclined to recommendations. Not respecting them would be felt as imperfection, impurity in compositional practice, violating the style. In spite of this it is possible to come upon violations of these obligatory rules in concrete examples of masterworks (a classic example of this type of "mistake" is the famous redoubling the leading tone in the motive of Vyšehrad from Smetana's *Má vlast*. It is possible to present this same "faulty" parallel octave between the bass and soprano in the third measure of the initial part of Mussorgsky's *Kartinki*, or the doubled dominant leading tone *f sharp* in the 12th measure of Chopin's *Ballade in G minor*). The presented violations of obligatory rules condense if we try to embrace all the categories of exceptions. Again the persistent question creeps in: Is it possible to theoretically formulate the presented exceptions? Why did Smetana dare to double the leading tone, while and adept study of classic harmony never does? This type of question is dispatched from the world as a reference to the composer's originality or genius, or "higher logic" of the presented place in the composition. Intuitively we feel that this type of answer does not satisfy us. Also we look for in corrections of "mistakes" at the presented places we show that those "faulty" solutions chosen by the original composer always sound better for some unknown reason.

In an attempt at a perfectionist's analytical examination providing the proper analytical experience, invention and observation perhaps we can demonstrate such infringements to a certain convincing measure as legitimate. In the case of the Smetana example - the counter-movement of the bass and soprano - the impropriety (non-distinction) of applying the appropriate III level chord, recommended by the standard rules of classical doctrine of harmony for similar eventual harmonization of the un-removed leading tone, the necessity to find a manner of regular separation of the leading tone (if that separation is not made impossible from the melodically latent soprano, another voice must assist it, in this case the bass). Another argument can be - in agreement with the composition's program - the intent of the whole archaic, that is fundamentally modally felt harmonic course (dominant fifth chord not actually representing the dominant function in the classical sense and not valid for it in those strict dimensions of classic rules). In the cited example of Mussorgsky it is possible to argue tectonically, eliminating "applicable inappropriate flaws" of the tonic sixth-chord "repair" to the fifth-chord in order to arrive at such a banal result. A further nonsensical solution is perhaps impossible to imagine. The banality of that attained music formulation, apparent at the first hearing of the plainly literal repetition of the motive founded on the two times stated sequence D5 - T5, would not in the least be able to compare with the solution which Mussorgsky chose: D5 - T6, D5 - T5. Mussorgsky's solution is ingenious, elegant, and dynamic. Mussorgsky's approach generates gradation, a tectonic process of sequential searching and subsequent locating of the resolving tonic: firstly after weakening the harmonic separation D5 - T6 sound convincingly the same as the subsequent tonic - in the melody of the repeated

soprano, harmonically however dissimilar - from the sequential D5 - T5. Additionally so said, that here - this time considering the Russian, that is Eastern European origin of the analyzed music manifestation - we can, for sure, in the "mitigating circumstances" in relationship to classic rules - state the fact that the tonality, however strongly modally colored, is not strongly obligated and responsible to the rules of classical harmony (compared for example to Brahms). The last cited example, Chopin: defending the doubled leading tone will be quite easy. The leading tone of the melodic line *f sharp* on the piano also quickly fades. Its "proper" omission in recognition of the accompaniment in the second measure would reach a single result, and that an unpleasant empty sounding of a pure fifth *d* - *a* in the part of the left hand. Is there some reason to insist on the compliance to the articulation of the "rules"? Further supporting arguments defending Chopin's "mistake" in the chosen piano composition are the musical lines of the right and left hand as the sound area is so factually mutually detached that it is necessary to analyze each one of them individually. In that case the doubled leading tone *f sharp* actually does not fade because each of the two *f sharps* is found in a different musical line.

It is certainly possible - along with admiration for the reader's patience and endurance to devote attention to the text of the preceding paragraph - to comprehend the logic and discern the humor of the bizarre pedantic argumentation, applied in the preceding paragraph. Each sentence is a deadly serious (and true, justified) statement of an objectively verifiable reality. However, to the judiciously thinking observer it is apparent that the factual contribution of this conceptual analysis is more than controversial for its single outcome is a shattering atomization of the observed reality into many minute fundamentally minor factors. Let's only briefly remember here Hindemith's "music theory mishaps" in an attempt at honest rational exact acoustic argumentation "in good faith" supported display of harmonic manifestations of tonal harmony of the 20th century and a formulation of the working rules for compositional practices in the well-known writing *Unterweisung im Tonsatz*: that "welding of theory with practice", respectively welding Hindemith's theoretic with Hindemith's compositions finally leading to an endless line of exceptions, which in their sum total actually refute, or in the least impugn the system itself. The error in our opinion does not lie in Hindemith's music theoretic inconsistency, as it seems in Emil Hradecky's writing, rather in the error originating from the conviction that it is possible to map the reality of the unmappable. What does this remind us of? Is that not similar to that vain effort to predict the weather by means of measuring the status and behavior of "every molecule" of the system?

To summarize and consider, the classic "rules" of the doctrine of harmony (prohibitions and directives of leading voices - compare to classic physical principles of levers, cables, inclined surfaces) begin to fail at the point when the system (harmonic phrase compared to weather) begins to behave not quite predictably in the consequence of further not quite controllable effects. Does that all not result into one illumination and conclusion that is that **music, musical expression displays, in significant measure, the markings of a non-linear dynamic system of anomalous attractors**? Now there remains nothing for music theory other than to make the step, which has already been made by meteoro-

logy, economics, physics, linguistics, demographics, chemistry, biology, ecology, geology, anatomy, prognostics, astronomy etc.

We cite again Wittgenstein: "The more thoroughly we observe the actual expression, the stronger the discrepancy between it and our claim. (Crystal clear logic *does not emanate from my recognition*; rather it was a requirement.) The discrepancy becomes unbearable; there is the chance here that the claim becomes somehow empty. We felt icy ground where friction is missing, where the conditions are in some certain sense ideal but to where for it we are not to go. We wish to but we need *friction*. Back to rough ground!" (Philosophy of Research, p. 107).

About music as a non-linear dynamic system

The above described musing over a few examples of music theory interpretation possibilities or commentary on music structure, respectively, musical language with assistance by classical European music theory built on analytical and systematic instruments convinces us - in confrontation with the results of published research in the area of chaos theory - if not about the necessity then surely in the smallest measure inspires us to attempt an application of some of the offshoots of chaos theory on the practice method of music theory with the hope that there can be discovered an avenues to finding departure points from that "crisis" to which - together with other European sciences at the end of the 20th century arrived - and to the recovery of a sensible avenue, justifying its existence as a trade of a capable person to reflect completely and deeply musical expression, respectively, music structure not as only a form of its character as a manifestation, but rather as a further step on the road to uncovering its foundations. This means, among other things, to subject it, in the light of chaos theory, to a discriminating scrutiny and certain revision of classic music theory discipline - doctrine of harmony, doctrine of form and tectonics, melody, polyphony, kinetics (metro-rhythmic) and others. We can expect the possible genesis of new perspectives of composition technology and methods such as classical as well as modern to the latest (respectively its more illuminative commentary), and many interesting questions and answers concerning music culture outside of Europe. We can as well anticipate the emergence of new perspectives in the general dimensions of music thought - music time, sound space, music movement and the like.

Let's return again to the consideration of a "music logic." We pose the question, is it possible to speak of a real logic in the case of a music manifestation which is not verbal? We ask then: Can we, in the case of music, consider the category of **logic** at all? Is it possible to ask the question: **Is music logical or not**? The Greek word *logos* means word, expression, idea! The essence of logic is an exact operation with concepts, statements, analyzing their relationships on the basis of the analyzed and stating of their trueness and falsehood and the like. Music however does not work with concepts and does not know statements! Operations with concepts and statements are rather the franchise of a language! In spite of this, however, we find that Hugo Riemann began his excellent mu-

sicological career with the dissertation ***Musikalische Logik,*** *Hauptzüge der physiologischen un psychologischen Begründung unseres Musiksystems* (Music Logic, The Main Features of the Physiological and Psychological Justifications for our Music System, 1873 - highlighting by this author). In common everyday practice, for example when analyzing students' compositional attempt, we say that the given management of the voices **lack logic**, manner of developing the surface and tectonic treatment and the like, **that it is or is not logical** and the like. What do we have in mind? What do we understand as that "music logic"?

Wittgenstein and others convinced us that even a language, a real living language lacks logic, or is long and far away from it - for every example of the Czech double-negative, undoubtedly complicating the life of foreigners studying our beautiful mother-tongue (see the citation from Wittgenstein at the end of the previous chapter). What do we mean if we declare something (anything!) as "logical"? The answer based on "common sense" could be: Logical is that which for us is intelligible, not countering our common experience. It could be a structure or a system whose internal make-up and function is completely comprehendible - for example the description of how a steam engine functions in which is a singular patent chain of events: water + heat → steam → excess pressure → pressure on piston head → movement of piston → movement of piston rod → redirecting steam pressure on the rear piston head → pressure on piston in opposing direction → reverse piston movement → piston rod movement → redirecting steam pressure on the front piston head → piston movement in the original direction... The interpretation in the spirit of the schematic chain reaction seems "logical" to us. "Illogical" - face to face with our common layman experience - can seem the conclusion of Einstein's Theory of Relativity: if a moving object approaches the speed of light, time slows down, dimensions shrink, mass dramatically increases. This is something that exceeds our common experience, which we cannot by "common sense" imagine. There is another example of a process, shy of our perspective of "logic". Many times in this study we have mentioned the weather and it development and changes and yet - in the case of weather we have to admit that indeed all of the known physical causalities function perfectly. Each is individually observable and demonstrable, but it is not, however in our abilities to register and consider the sum total of all the billion of minute causes participating in that chain reaction! We perhaps agree to accept that the weather has its own particular **living** "logic" and we lack the ability to understand it with the apparatus of our **artificial** "logic", constructed and developed from rational traditional classic European sciences?

We may ask which of the presented model examples of structures such as language, music (prospectively other similar ones which are not the subject of this study) from the standpoint of the analytical questions of "logic" and our capability of their "logical" interpretation are most similar to that example of the steam engine or weather? Supposing that we do not allow too many errors, we acknowledge that at a certain level of knowledge, the corresponding classical age of enlightened rationalism, undoubtedly like linguistics (in analyzing the structure of a language), as well music theory (in analyzing the structure of music) we could view the subject of our research by that classic "logic of common sense", that is as we indicated by the model example of explaining the func-

tional structure of a "steam engine." In the case of music theory this level of knowledge corresponds for example to the systematic of classical harmony applying ideas such as key, accord, harmonic function, systematic polyphony working with clearly defined ideas such as imitation, real and tonal response, canon or systematic tectonics and music form judging the motif and thematic identity and contrast, reprise (restatement) of thematic material, varying variations and sequential motif and thematic contexts. Similar to our description of the steam engine neither does classic music theory include in its consideration that "friction, wind resistance, uneven surface" which in the case of the steam engine and classic music form otherwise likewise occur. However, thanks to its patent negligibility it does not influence in any manner the fundamental function of the system as a whole. So said, it is apparent that this cannot be applied - without which we would encounter significant problems - in the construction and reading function of the computer management of an atomic reactor, nor in the harmonic and tectonic analysis of 20th century music - that where Debussy, Skriabin and Schönberg begin. Of course not to speak of what follows, the same of course of that which originates elsewhere than from Europe. Observing and interpreting that reality through the prism of "classical logic" does not lead to a further broadening of knowledge where it is necessary to accept the appeal of "logic" of chaos theory. How concretely? There is no simple answer to that question. If there were the task would be finished and music theory would be a step further.

In closing we present a few remarks, indicating possibilities and directions for further consideration.

In the process character in the temporal course of a music structure it is possible to ask if it is at all possible, in our potential survey of music, to search for the "logic" of its course to discern and distinguish that which is not exactly comprehendible, verifiable or accessible for our "common sense." Regarding the rules of music "grammar", we have apparently in mind, not only that which is learned "by heart" from harmony, polyphony and other textbooks, but those **real rules** ("real logic"), giving music manifestations order and sense, therefore about those real rules it would be possible to say that which Wittgenstein wrote about he rules of grammar in the original - that is lingual - literal sense. We repeat: "One learns to play the game by that which one **observes**, how others play it [...] some **observer** can **infer from practice** that game." What does that mean in relationship to music thought? Is it possible for example on the basis of an analysis of the course of ten measures of music ("observing, examining, inferring rules") to state the course of the further continuation? No it isn't! We cannot pose that question at all! If we could answer "yes", the music course would present in time a developed chain reaction of interconnected events. We would allow a mechanically determinable character to music structure; the second measure would be determined by the first, the third by both previous measures and so on. The first measure would be determined by the whole composition. By composition of the first measure the composer would fulfill his intention. The remaining would only be mechanical practice which could be completed by a computer. If we answered to the contrary "no" based on the analysis of the ten measures it would not be possible to determine the further course. We would allow the possible of arbitrary direction and man-

ner of continuation with need of a context. The question itself is of course fundamentally erroneous. Similar would be the case of the question if at the beginning of a chess game it is possible to determine its further course and result of the match. In this context we can mention anecdotally Wittgenstein's story of the pupil who upon given the task "continue the sequence of the given sequence of numbers 0 - 2 - 4 - 6 - 8 - 10 - 'continued with' 15 - 20 - 25 - 30..." Upon correction by the teacher that the pupil did not comprehend the basis of the sequence upon which "each number was 2 greater that the preceding one, the pupil answered: 'From the given system I deduced the following rule: from zero to ten every number is 2 greater than the previous, from ten up every number is 5 greater than the previous one. '" We could endlessly wrangle about whose argument is logical, respectively, more logical.

From both examples it is evident that the real rule about which we are speaking concern music not as a causally interconnected sequence in time of distributed musical structure elements ("music form as a process" is not the same as a chemical trial!), rather as an endless - but not completely boundless - aggregate of potential possibilities. As in the case of the chess game as well in the case of our pupil from Wittgenstein's story, and also in the case of newly arising music or language structures in the complete course of the process - also in everyone of its individual moments - blend mutually the two tendencies. The first of them is the mentioned **causality factor** (each of the two players in the chess game react out of necessity to the current course of the game, particularly the last move of the opponent, he cannot then arbitrarily move). The other tendency is the **teleological factor** (each of the two players intends - and that with every move - to a set goal which is victory in the chess match, that is booby-trapping and concocting check-mate to the opponent). **Through mutual counter-play, penetration, interference of the mentioned factors - causality factor and teleological factor - the game arises**, the concrete course of play with all its possible twists and turns. **The playing rules are for both players the framework in which they may realize their moves. They are not instructions of how to begin a winning game**, nor do they contain any type of "hidden algorithms" of logic contemplated by a chess-master.

We apply the chess game example to music. A concrete music structure - in the sense of compositional and interpretational - displays in the process of its creation the same. That is a mutual working, interplay, intersection and interference of both stated factors - causal and teleological. The causal appears in the sequence of what occurs: in **composition everything which was written** (every measure, every note), in interpretation **everything which is heard** (every tone, every accent, and every dynamic or agog wave), everything that **directly influences further progress and continuation**. We mention that causal affects can result from physical givens (the material of music is sound, that is, the physical fact of oscillation, and every further consequence of that fact, particularly - but not only - harmonic), from anthropological givens (music must be sounds found in the zone of audibility, rhythmically effective time intervals must be found in a zone bounded between time differentiations and between kinetic stagnations). Furthermore, a large scale of psychological factors applies. On one side the desire for change and on the other,

however, at the same time the tendency to preserve, retain the current status and finally from sociological givens (compositional, stylistic, genre requirements resulting from the societal function of music and its changes). The teleological factor is given by its own musicians' decisions, by choices at each moment of the creation of the work (each choice a result of a spontaneous idea, deep consideration or mere coincidence) that **decision** is, in that case, subordinated to the goal which is, at that time, the above mentioned in detail negotiated **ideal music form**. Here in passing - with mention of the above detailed discourse of the fractalness of music structure - we state that both factors, causal and teleological, always in some manner project into all of its hierarchical levels. It is also necessary to note here that there does not exist only one possible idea of the "ideal form". In that respect there is an abysmal difference between the ideal form in the imagination of J. S. Bach and the ideal form which a musician diametrically removed from European culture and music strives for.

Inspired by linguistics, working with Saussur's dual aspect of the *langue - parole* language (langue = a universal system of language, parole = its actual or potential realization, discourse) we can state (an expressed example testifies to it) that in the analysis of the character of those "real rules" and striving for their discovery, decoding and systematic formulation we can have in mind that **we are searching for "the language of music" and that on the basis of studies and analyses of many examples of the "parole of music"**. There is no doubt that linguistics which already in that field - also applying chaos theory - has done a lot which would provide music theory with many methodological examples - keeping in mind the many differences between language and music.

In the analogy (and potential sketch of cooperation) of music theory and linguistics we continue further. It can be stated that neither the structure of language nor music are in a static state, rather are in a continuous progression. Language and musical expression undergo a continual process of development in time from the result of the influence of the most various effects - internal and external. At each time point of that process there is a given fact of **plurality** - existence of many languages (spoken and "music") at the same time. Their continual and mutual influence, blending, permeation, intersecting, earlier particularly in geographical adjacent locations of individual language areas, today in the explosion of the information age, effectively everywhere - without limitation. The presented **convergence process** (confluence) is markedly graduating already as early as the last century - and particularly recently - thanks to the aforementioned swift development of information technology, media and manners of spreading music and information about it. The convergence however was a natural fact in the past and long before the development of recording technology and the information boom: in the case of analyzing the "language of music", see the mutual penetration of jazz and classical music at the beginning of the 20th century, or even earlier - the penetration of spiritual and secular music, national cultures in the context of various societal and politically historical processes and as the result of the emigration of musicians in various periods. The described process reminds us of the example of the ink pen dissolving in a glass of water and inspires the image of the second thermodynamic law taking affect here and after some time coming to

a perfect mixture whose result with be a single "language" - in the area of expression and music - that is it comes to the fulfillment of the maximal value of entropy. Nevertheless, similarly as physics ascertained, we, eventually, will necessarily come to the conclusions for our considerations, that the second thermodynamic law does not function so simply as at the time - in other historical situations and at another level of knowledge - when it was formulated. Our conclusion undoubtedly results from recognition of the reality that in the process of development of both of our "languages" - the verbal expression and the language of music - function simultaneously, in a circumscribed natural process of convergence (conflux) and reverse process - **divergence** (splitting), observable as in the development of language (we take into account the scores of variants and mutations to which every language has achieved - Romantic, Germanic, Slavonic, in the course of two-thousand years), thus so in the development of musical expression. We again take into account the scores of personal composition styles which, for example, the generation of classics of the first half of the 20th century, developing the common classic foundation and continuing it with Stravinsky, Schönberg, Berg, Prokofiev, Hindemith, Honegger, Bartók, Weber, Suk, Janáček, Martinů and others. While classic music "language" was singular, it embodied a single common "grammar" of classic harmony, melody, form and tectonics. "Mapping" music expression of the presented modern classics on the basis of a common denominator of a single "grammar" is impossible.

It can be stated that all impressive, multi-layered and rich processes of development of musical language in the sense of *langue* is a process of mutually **interfering processes of divergences and convergences within the continuous operation of causal and teleological factors.** A particular subject of these processes is music. That is the inexhaustible scores of concrete current and potential music structures in the sense of a *parole*. Neither in that elegant statement, generalizing to an apparently luminous formulation of everything that participates in the development of music, we are not spared further related uncertainties; for example questions of actual measures of influence of the creators concrete contributions of this or that, singular and unrepeatable characteristics upon the course of the whole development. Here need not apply generally the greatest influence arising automatically from the expressiveness, originality and value of the manifestation itself. To its enforcement sometimes can contribute other factors outside of music intentionally and completely coincidentally (compared again to the butterfly effect). Sometimes a work can exist completely inconspicuously, undiscovered and underestimated, surrounded by grey mediocrity and convention, and its discovery, understanding and the development of its influence can come later, in later generations. It would be certainly possible to pose the question, would the talent of an individual such as Bach, Mozart, and Beethoven apply and develop in another historical situation, for example today? That would be a consideration at the level of science fiction.

It is necessary to have in mind, also, that the circumscribed realities (the interference of processes of divergence and convergence, causality and teleology) apparently occur completely differently, according to another modeled scheme in European culture in which was generated - thanks to a record - conditions for preservation, resurrection and

redevelopment of music phenomena of the past and those of cultures which do not have a music notation system and in this framework transfer music information from generation to generation only directly by a verbal tradition. In these conditions European music culture obviously would manifest completely different.

Prior to a final conclusion we cannot omit a note that the frequency of changes of our speculated "language" (music language and language in the original sense of the word) in time embodies, from long term detached notable margins, which fundamental changes in the language occur in the rhythm of centuries or millennium, fundamental changes in the "language of music" in principle play out in the course of decades to centuries (stylistic epochs). The presented comparison can be supplemented with reference to the "ephemeral" life of fashion waves, at the same time influencing changes in music thought - particularly in the area of non-artificial music - in the course of a year to a decade. Comparing the presented frequencies of changes we can state another - this time **temporal fractal** of all our considered processes, playing out in similar and however varying - and mutually notably distinctive - coursing hierarchical levels of the time dimension.

We close stating that music, musical expression; music structure is one great *anomaly attractor* - with all those attributes: bifurcation, entropy, contingency, non-linearity, uncertainty, and instability, formlessness, dispersing possibilities, butterfly effect, interfacing, complexity and fractalness.

Musical expression, a quite non-linear dynamic system par excellence unequivocally represents a challenge to music theory at the beginning of the 21st century.

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Zusammenfassung

Die Theorie des Chaos ist eine mathematische Disziplin mit Ausrichtung auf das Studium von nicht linearen dynamischen Systemen, d.h. von komplizierten Erscheinungen, deren Entwicklung im Laufe der Zeit nur schwierig vorhergesagt werden kann. Ein solches System können beispielsweise das Wetter, die Entwicklung von Kapitalmärkten, die Turbulenzen, das Wachstum und die Entwicklung von lebenden Organismen, das Ökosystem und sein Entwicklungsprozess, die Frequenz und der Verlauf von Erdbeben, die Sprachen und ihre Entwicklung, der Prozess der Entstehung und der Ausbreitung von Epidemien darstellen... Wie aus den wenigen angeführten Beispielen hervorgeht, erfolgte die Wahrnehmung des Phänomens Chaos und die Entstehung der Theorie des Chaos unter Zusammenwirken, bzw. auf Anregung mehrerer wissenschaftlicher Disziplinen, die verschiedene Erscheinungsweisen der Realität vom Natur- sowie gesellschaftlichen Charakter erforschen: Meteorologie, Ökonomie, Physik, Linquistik, Demographie, Chemie, Biologie, Ökologie, Geologie, Anatomie, Prognostik, Astronomie usw. Die Entstehung der eigentlichen Theorie als einer neuen Betrachtungsweise der Realität wird insbesondere mit dem Namen des vielseitig orientierten amerikanischen Mathematikers Benoit Mandelbrot verbunden und an der Wende der siebziger und achtziger Jahre des 20. Jahrhunderts zeitlich angesiedelt. Weitere Bahnbrecher der Theorie waren u.a. der Meteorologe Edward Lorenz, die Mathematiker Stephen Smale und Mitchell Feigenbaum, der Biologe Robert May, der Physiologe Bernard Huberman, der Matematiker und Physiker Robert Shaw, der Chemiker und Physiker Ilya Prigogine, der Geophysiker Christopher Scholz. Die Theorie des Chaos bewertet das Chaos nicht als Geschehen ohne Ordnung, sondern im Gegenteil als eine bestimmte bisher nicht erkannte Form einer Ordnung. Es zeigt sich, dass die wirkliche Naturordnung gerade in dieser Weise verstanden werden kann.

Die Theorie des Chaos schuf einen Komplex von Begriffen, mit deren Hilfe sie ihren Gegenstand erfasst, z.B. Bifurkation, Entrophie, Phasenraum, Zufälligkeit, Unlinearität, Unsicherheit, stochastische Prozesse, Instabilität, Fraktal, sonderbarer Atraktor. Wir sind davon überzeugt, dass die Musikstruktur und die Musiksprache alle Merkmale eines nicht linearen dynamischen Systems aufweisen. Wir haben genug gute Gründe für die Auffassung, dass es unter den oben bezeichneten wissenschaftlichen Disziplinen auch für die Musiktheorie Platz gibt. Die Untersuchung der Fraktalstruktur der Musik macht z.B. ein tiefgreifenderes Verständnis ihrer harmonisch-tektonischen Ordnung möglich. Die

Anwendung der Theorie des Chaos bei der Musikanalyse kann die Aufdeckung solcher Beschaffenheiten der Musikstruktur ermöglichen, die uns beim Einsatz von herkömmlichen Methoden der Musiktheorie bislang verborgen blieben.

Resumé

Teorie chaosu je matematická disciplína, zaměřená na studium nelineárních dynamických systémů, tj. složitých jevů, jejichž vývoj v průběhu času lze těžko předpovědět. Takovým systémem může být například počasí, vývoj kapitálového trhu, turbulence, růst a vývoj živého organismu, ekosystém a proces jeho vývoje, frekvence a průběh zemětřesení, jazyky a jejich vývoj, proces vzniku a šíření epidemií... Jak je zřejmé z několika uvedených příkladů, k uvědomění si fenoménu chaosu a zrodu jeho teorie došlo za spoluúčasti, resp. z podnětu více vědních disciplin, zkoumajících nejrůznější stránky reality přírodní i společenské povahy: meteorologie, ekonomiky, fyziky, lingvistiky, demografie, chemie, biologie, ekologie, geologie, anatomie, prognostiky, astronomie aj. Vznik samotné teorie jako nového pohledu na realitu je spojen především se jménem mnohostranně orientovaného amerického matematika Benoita Mandelbrota a časově je situován do období přelomu sedmdesátých a osmdesátých let 20. století. Dalšími průkopníky teorie byli meteorolog Edward Lorenz, matematikové Stephen Smale a Mitchell Feigenbaum, biolog Robert May, fyziolog Bernard Huberman, matematik a fyzik Robert Shaw, chemik a fyzik Ilya Prigogine, geofyzik Christopher Scholz aj. Teorie chaosu posuzuje chaos nikoliv jako dění, postrádající řád, nýbrž naopak - jako určitou dosud nepoznanou formu řádu. Jak se ukazuje, právě takto je možno porozumět skutečnému řádu přírody.

Teorie chaosu si vytvořila soubor pojmů, jejichž pomocí se zmocňuje svého předmětu. Je to např. bifurkace, entropie, fázový prostor, nahodilost, nelinearita, nejistota, stochastický proces, nestabilita, fraktál, podivný atraktor. Jsme přesvědčeni, že hudební struktura a hudební řeč vykazuje všechny znaky nelineárního dynamického systému. Máme dost dobrých důvodů pro názor, že mezi oněmi výše jmenovanými vědními disciplinami se nalézá místo i pro hudební teorii. Zkoumání fraktální struktury hudby umožňuje např. hlubší pochopení jejího harmonicko-tektonického řádu. Uplatnění teorie chaosu při hudební analýze může umožnit odkrytí těch vlastností hudební struktury, které nám při uplatnění tradičních metod hudební teorie zůstávaly skryty.