

# Applications of Logic to Music, within the Context of the Scientific Approach Structure

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## ABSTRACT

In Ancient Greece, the seven liberal arts were taught on stages. Grammar, logic and rhetoric were taught within the *Trivium* („three paths”) ensemble. The superior stage, *Quadrivium* („four paths”), a view attributed to Boethius in the 6<sup>th</sup> century A.D., was comprised of arithmetic, geometry, music and astronomy. Today, music is still joined with the exact and humanist sciences in numerous interdisciplinary studies. Beside other methods of musical analysis, the exploration of facts in the light of the logical reasoning also attaches music to the objectivity of science. Precisely because it is sublime, permissive and unbounded due to human subjectivity, music offers the possibility to arrange it easily inside the boundaries of a scientific research. The logic-music coupling is presented, therefore, within a well-known framework starting with the observation of a fact and ending with the envisioning of predictions.

## Keywords

Music, logic, interpretation, truth, fact

## INTRODUCTION

The structure of a certain scientific approach is validated due to a sequence of methods of research, assessment and prediction in a certain field, each of these methods participating with its methodological subsections.

The order of the epistemological procedures cannot be changed because the essence of interrogation itself would be negated and the entire research would flounder in paradoxes. For instance, in order to look for a model universally compatible with a reality included in the model, it is necessary first to make a statement regarding the observation of a fact. On the other hand, in order to start a study resulting from a hypothesis, it is necessary to first verify the falsifiability of the hypothesis.

The application of reasoning originating from logic concerning musical phenomena and processes as part of an interdisciplinary research starts with a question: is music or not capable to hold the potential for convergence of the creation concepts with the logical thinking?

Having history as a working material and the evolution of musical styles as a method of analysis, the scientific inquiry seems to favor the possibility of bringing closer, to some extent, the creative act to objectivity. The latter remains in our conception a combination

of immanent and transcendent. However, since the verb *to create* is determined not only by the verb *to perceive*, but also by the verb *to judge*, it is eventually found that the mental activity appeals unintentionally to the logic described by reason and so it can also be seen from this angle

### **The semiotic nature of truth in science**

A sentence is elementary if it is based upon its two elementary poles: the object and the expression or the sign and the functor.

In semiotics, truth is expressed in the simplest ways to be expressed through elementary sentences. In order for a sentence to be elementary, an object (a sign) must be accompanied by an expression (a functor). The object accompanied by its expression builds thus an elementary sentence, made of one or more signs and of at least one functor. The sign without a functor has no kinetics, similar to a music that has not been played yet. The functor without a sign has no name, similar to a music of which only the tempo is known, without knowing actually what is being played. Only together the sign and the functor congeal a semiotic or musical structure.

Any truth in science is (stays as) a temporary truth, valid until being contradicted with the next hypothesis that has become a theory. A theory is a hypothesis verified repeatedly by experiments, on the basis of which prognostics can be made. What does truth consist of? Any truth is made of elementary sentences in the least. What are elementary sentences in semiotics? Scientific research operates only with statements and interrogations, the transformational functors of which can modify the expressions of the object.

If the reasoning of logic is valid everywhere and the world is everywhere, then the semiotic sentences are universal too, insofar as they are logical and refer to the condition of the world. Verbalized music, seen in all its aspects through at least elementary sentences, can enjoy universality, being verified with scientific research, once again in addition, due to the universality of the world and logic (Carnap, 2003). Everything, in the condition of the world and in the world of sound is manifesting binary: from the point of view of the object that is carried, about which it can be said that it exists exactly because it is carried; as well as from the point of view of motion, about which it can be said that it exists exactly because motion carries an object.

The sign and the functor, or the object and the expression, or the sound (with timbre and intensity) and its length, or the score and its interpretation building an elementary sentence, generate a fact (artistic). In order for that fact to take place, the functor must make a selection from a varied range of objectual aspects. Respectively, in order for the fact to be generated, the sign must select from a variety of expressive possibilities. If the fact is produced due to fulfilling the necessary condition of the relation between sign and functor, the sentence is true. And if the fact is not produced, the sentence in discussion is false. Therefore, we say about facts that they take place or not and we state about sentences that they are true or not, depending on the fact. The methodological apparatus of a scientific research that determines the degree of truth of a research is configured as a possible semiotic world of research. The world of the ensemble of factors determines the value of a research made of true or false statements.

How valuable is a truth? Without intending to analyze here the notions of *truth*, *world* and *value*, we only state that the sentences that are true have values given by a scientific methodology, which is the condition of the ideatic, semiotic world.

## **METHOD**

### **Observing some facts**

The scientific approach can be structured according to the observation of some facts. Observation as part of an investigation comes down to drawing attention and inciting through revealing a reality that is about to be searched empirically. By means of observation, the existence of an event that stirs curiosity can be found.

The enunciation of the observation would be the following: *The historic periods of the sonorous conceptions are not juxtaposing but superposing. This means that the final temporal segment of a certain sonorous conception is concurrent (diacronic) with the temporal starting segment of the next sonorous conception.*

### **Formulating some problems**

By observing the fact that the historical periods of the sonorous conceptions are not juxtaposing but superposing, fact that takes place in a certain testable reality, the questions about the relation between the object observed and the observer subject are born. The role of the dubitative sentences is to form the problems, later involved in the structure of the scientific approach. In the domain of music, being formulated as problems, there are notions that continue to remain subject to the scientific processes, such as: *the density of the representatives of each stylistic trend; the moment of beginning and ending of each stylistic trend; properties of each stylistic trend; paradigmatic renewals through different periodicities; defining the characteristic terminology.*

### **Creating the model**

The observed fact of historical periods, of sonorous conceptions that do not juxtapose but overlap, in all its complexity, can be part of a model. Models are patterns of terms and relationships with universal validity or, in any case, with a particularly semantic area. In the present case, the observed fact is part of a general movement from a first value to another, different from the first, this model being called *evolution*.

### **Proposing a hypothesis**

Scientists' doubts and reservations reject dilettant empiricism, the desire to penetrate unscientifically into essences. Referring to a philosopher of science, Karl Popper, any scientific activity must be based on the logic of methodological research.

The pursuit of scientific research, going beyond this stage, continues with the organization of experiments, lot studies, etc. But we intend to stop at this stage. We propose only a hypothesis and point to the framework of a scientific approach based on the applications of logic in the analysis of musical phenomena, supporting the observations and reasoning that require provisory explanations for certain phenomena.

Any existing sonorous conception offers the conditions of its evolutionary path to the next sound conception. The latter is a stage of completing the first. *Each preconceived sound conception provides training conditions for only one evolutionary path towards the formation of a new sound concept* – is the statement of the hypothesis.

The above can be supported by an example. The evolution of the parallel movements of octave and fifth voices led to the formation of the concept of major trison. The beginning period of *Ars Antiqua* vocal polyphony dates back to 1150 and has as a representative, among others, Leoninus, a prime example in favor of the hypothesis. The two-leading-tone cadence formula has led to the consolidation of authentic-type cadence into harmony. The beginning the *Ars Nova* period dates back to about 1350 and includes, among others, Francesco Landino, a second example in favor of the hypothesis.

### **The falsifiability of the hypothesis**

Intuiting the validity and anticipating the verification of a hypothesis will not be able to attract but a formal acceptance of the hypothesis, until it passes through convincing experiments which have the means to confirm or refute a hypothesis. If every time the experiments lead to the same result, it is only then that we have a theory. The experiments must be controlled, in order to remove the variables that can inadvertently affect the result. The experiments must be reproducible. The hypothesis must be falsifiable, so it must not be a simple opinion, a baseless statement. The hypothesis cannot be proven in itself, only the data within.

Regarding the falsifiability of the hypothesis in music, we can state that the germs of the musical geometrical structure, with the emergence of the chord segments  $\alpha$  (of the diminished chords of diminished seventh, without the obligation to be resolved) can be located in the works of Johann Jakob Froberger, Jean Baptiste Lully and Arcangelo Corelli, in the 17<sup>th</sup> century and the beginning of the 18<sup>th</sup> century. This manifestation is simultaneous with the renewal of the modal musical language through the harmonic functional tonal system. In other words, the forming of the tonal-functional system in the Baroque takes place in the same period with the emergence of an incipient stage of the geometric structures, namely the type  $\alpha$  chords, also from the Baroque.

*The modal world of music in 1550 was followed not only by the accomplishment of the tonal harmony, but also, concomitantly, by the emergence in the musical world of the geometric systems* – it is a statement that contradicts the hypothesis. The modal world offered evolutionary conditions for two orientations. This assertion argues the falsifiability of the hypothesis through a contradiction of the hypothesis. Or, to the same effect, the assertion according to which any sonorous conception offers evolutionary conditions only for one single sonorous conception is false.

### **Applying to music some methods of the cognitive sciences**

#### ***Modelling***

Most often, wanting to follow the proposed higher-level benchmarks of scientificity (why not *imposed*?) – at at the level of supreme epistemic performance – in the neo-positivist philosophy where some pedagogues and philosophers such as Vladimir Guțu and Carolina Țurcanu (Guțu & Țurcanu, 2016) do research, the cognitive sciences relate to the reality sector subjected to research by modeling (or *modelizing*).

Thus, the simulacry of things, phenomena and processes in themselves, meaning simplified and substitute schematic artificial reproductions are being constructed and studied. In essence, after identifying the model (in our case the evolution), we establish the hypothesis of an analogy between the model and a system distinct from it (according

to this article, the *relationship of two historical periods*). The next step is to formulate some relations of transformation from model to model and to build a simplified system.

It can be discerned here a certain intertexture of subjectivity with objectivity. The objectivity (representing the model) starts from the postulation of axioms and rules chosen without morality, in order to chain later on the theorem corpus in a deductive-consistent manner. Similarly, subjectivity (representing the modeled) implies the initial freedom, motivated also psychologically, of cutting and extraction, selection and choice in favor of some of the parameters, factors and properties of the facts examined in the model (of course, ignoring or neglecting others). After that, the statements are ordered in rigorous, solid, coherent, edifying ensembles. The method is suitable to be instrumental both ideologically and practically, the cognitive sciences reserving their recourse to both procedures.

The statement of the model could be as follows: *The relationship of two historical periods can be defined by the specific features of each version of the relationship between the historical periods*. Two neighboring historical periods can be found in the following relationship variants: the two periods are successive; the two periods intersect in their sequence, that is, the final moment of the first occurs at the same time as the moment of the second; the reality of the second period is anticipated germinating in the reality of the first, a relationship we now called *anticipated early conceptual practice*; the reality of the first period is prolonged within the second period, a relationship we now call the *late finalizing conceptual practice*. Which of these four variants of the relationship between the periods of music history is the one observed? In order to start this study, modeling is needed.

### **Incomplete (or amplifying) induction**

Amplification induction is the mental operation that translates from one or more facts to the law of all facts of the same type. Psychologist Mielu Zlate uses a syntax relevant to the mechanism of incomplete induction: if a stage generates another stage, they are in a "generative succession relationship" (Zlate, 1999, p. 275).

In our case, the finding is expressed by the transition from the conditions of the Renaissance and Baroque instrumental polyphony started in 1530 to the system of gravitational harmony and geometric harmony, with the advent of Classicism and Romanticism. Also, the laws of all acts of the same type are musically expressed through the totality of sonorous conceptions. In other words, the observations made on one or a few particular cases extend to the entire class without being researched element-by-element.

Incomplete induction is based on an incomplete enumeration, executing the generalizing leap from one (or, usually, some) to all. This means that a property or set of properties is attributed to an unspecified number of unknown individuals of that class of objects or phenomena. Its principle could be formulated as follows: what is true for  $n$  cases is true for  $n+x$  cases, where  $n$  and  $x$  are close numbers. Naturally, for  $n$  individual situations, generalization is totalizing, the amplification starting with  $n+1$ . Such an approach occurs almost inevitably in any experimental activity, for, observing a fact once, twice,  $n$  times, it is admitted that it could be observed  $n+x$  times, so it is indefinitely reproducible. To many empiric philosophers, incomplete induction has appeared as the

only interesting and fertile cognitive method, a bold, fast and economic means of enriching human knowledge.

It does not follow that amplifier generalization would be free of problems and controversy over its grounds, or the confidence that can be given to it. A first point to be made is that the justification of this process requires establishing the conditions under which the expansion of our knowledge beyond the data of the experience can be operated. In other words, with what right do we conclude more than we have noticed, what legitimates the extrapolation to empirically unverified situations? Beyond the heated disputes about such matters, we find that the leap from the known to the unknown approaches the incomplete induction of the scientific hypothesis, which means that, in principle, the possibility of error can not be excluded.

At the same time, the generalizing conclusion carries a dose of risk, as it derives from the individual data taken into consideration not with certainty, but with a certain probability. Validation of the entire inductive approach requires verification that, in the field of experimental knowledge (including the field of psychology and parapsychology), proceeds as follows: one or more of the unchecked cases are selected, testing afterwards the validity of the amplifier conclusion by actual experiments. We thus see the close relationship between the made-up generalization and the customization through which the solidarity between induction and deduction is to be implicitly tested.

### **Mediated interferences. The categorical syllogism**

The mediated interference is the form of reasoning where the conclusion derives mostly from a premise and the categorical syllogism represents its (deductive) fundamental type being made of categorical sentences. When it consists of only three such sentences, the syllogism is called *simple*, having two premises and one conclusion. Let us see the following example:

- Minor premise: The period of instrumental polyphony after 1530 starts with a favorizing modal world.
- Major premise: Both, the gravitational harmony and the geometric one are in a relation of generative succession with the period of instrumental polyphony.
- Conclusion: The modal world favors the emergence of generative factors of both the gravitational and the geometric harmony.

As it can be seen, the premises have a common term (the "period of instrumental polyphony") and the conclusion has as its subject and predicate the uncommon terms of the premises (the "modal world", respectively "gravitational harmony and geometric harmony"). The common term of the two premises (the "period of instrumental polyphony") that is not concluded is called the *median term* of the syllogism, while the terms that appear in the conclusion and in one of the premises are called *extreme terms* (the "modal world," respectively "gravitational harmony and geometric harmony"). *The extreme* that ultimately fulfills the role of the predicate ("favors") is called *major term* while *the medium term* that plays the role of the subject (the "modal world") is called a *minor term*. The *major premise* is the one containing the predicate of the conclusion

("favors" or "puts it in a generative succession relationship") while the *minor premise* contains the subject of the conclusion (the "modal world").

For the sake of convenience and uniformity, it became a habit for the categorical syllogism to be presented by writing (speaking) first the major premise under which the minor premise and, finally, the conclusion separated by the other two statements by a line or preceded by the words "so", "thus" etc., which indicates a deduction. In the context of the current speech, this order of enunciation of the three sentences may not be respected, which does not mean that it is not a syllogism or that its validity is affected. It is defined as the *standard form* of the categorical syllogism that particular expression which is subject to the following three conditions:

- a) all three sentences are categorical (expressing only one report, concordance or opposition, between two terms);
- b) the two occurrences of each term are the same;
- c) the major premise is formulated first, the minor premise second, while the conclusion, third. Naturally, when these guidelines are not respected, the various alternative forms of syllogism can be brought to the standard form.

### Reasoning through analogy

The reasoning through analogy is the one that attempts the transfer of one or more properties from one object to another, however not in a general sphere, based on the relation of similarity between objects. In principle, if two objects ( $x$  and  $y$ ) are alike regarding some properties (relation designated with "=") and, moreover, it is determined that one of them meets the property  $P$ , it is concluded that the other one has the same property. Schematically: if  $x = y$  and  $x$  has  $P$ , then  $y$  has  $P$ .

In the history of music there is, in this case, the following correspondance with the reasoning by analogy presented schematically:

*Ars Antiqua* (object  $x$ ) lasts ca. 200 years.

*Ars Nova* (object  $y$ ) also lasts ca. 200 years.

So *Ars Antiqua* = *Ars Nova* as length of the affirmation and development of the sonorous conception ( $x = y$ ).

*Ars Antiqua* has two developmental stages: from Leoninus to John of Fornsete and further to Giovanni da Cascia ( $x$  has  $P$ ). Considering these, *Ars Nova* also has two development stages: from Giovanni da Cascia to Josquin des Près and further to Tomás Luis de Victoria (then  $y$  has  $P$ , too). If the relation between the similar features and property  $P$  is needed, then the conclusion will be certain, but if that relation is only contingent (by chance, accidental), the conclusion will be probable. In this second case, enriching the plausibility of the conclusion depends on meeting a few conditions:

- the similar attributes of objects to prevail over those who distinguish them and to be more important;
- to take into account the most numerous and more specific common notes;
- the property transferred from one object to another should be essential;
- the bond between the essential property and the rest of the common features should be as tight as possible;
- the conclusion should be as modest as possible in terms of what it claims.

Analogies play a considerable role in the actual scientific research, because not only are they at the bottom of the modelling process, but they also suggest hypotheses, assumptions of theorems that express causal law relations etc., which are to be tested afterwards. Concurrently, they support predictions which undergo the same exigency of subsequent verifiability.

### **The extensivity of the hypothesis**

The prognoses derived from the hypothesis must be tested. The conclusions and the prognoses must always be grounded on the theory already created. Erroneous prognoses initiate the consideration and generation of corrections or alternative hypotheses. Thus, internal inconsistencies, gaps, unexplained phenomena can be removed. The new hypotheses (the alternative hypotheses), are to be tested as well.

In order to take further this hypothesis, it will be necessary to engage in subsequent interdisciplinary research, so as to:

- find a universal model, previously imagined, of a presumptive reality that is to be interrogated;
- find a class of phenomena, as large as possible;
- apply a set of fundamental rules to develop a controlled experience;
- watch that model sizes are related to observations;
- to proportion the existing invariants to variables – which must be much fewer than the invariants;
- to ensure that the predictions of the results of future observations and experiments also find a place in the respective research;
- to provide falsifiable predictions by observations to be made following the experiments;
- to leave room for further research, meaning that the thesis (or hypothesis) allows further study, is extensible;
- to take care that the new experiments correspond to predictions, validating the allegations;
- to ensure that, when finding observations that are nonconforming with the predictions, the theory is subject to change or abandoned;
- to doubt as little as possible the competence of collaborators or people who issue ideas and make the necessary remarks.

## **DISCUSSION. OPPOSED POSITIONS**

### **Positions *against***

It could be said that things were pushed a little too far. Logic is a branch of philosophy and the latter can be used to create the poetic interface between the generative and the musical ideas of the the continuous transformational flow from extramusical to musical. However, according to some scholars, the stimulation of intuition would satisfy the intention to broaden the interpretative semantic horizon in musical expression, without having to resort to connotations carried out by correspondences with other domains. In this sense, the composer, writer and philosopher Leonard Meyer affirms that the phenomena explained by the natural sciences over the past 300 years have boosted

today's sciences onto venturing on grounds such as as creativity and originality in human activities. As a result, the arts, for example, were able to benefit from the efforts of serious intellectual deepening (Meyer 1980, 177-205).

Physicist Geoffrey Chew from the University of California argues an unfavorable situation for the old Newtonian-Cartesian paradigm, as such unfavorable as well to the constraint of logic on musical phenomena. Today's observations of the world, viewed from the point of view of current findings, do not allow the analysis of the world with a logical system. The inconsistency of logic with the nature of the observed reality lies in the assumptions, approximations, and probability of events occurring and results in the use of statistics in their classification. One of the theories of today's physics conveys another type of relationship between the familiar objects of study, also adding new notions to Aristotle's logic. Until the 19<sup>th</sup> century, in physics the objects were thought as separate from each other. Today, these objects are said to exhibit a multitude of interactions which makes the properties of some to cause the appearance or the alteration of properties of other objects; furthermore, that the part contains the properties of the whole and vice versa, similar to a hologram. From the intercausality and the metonymy shown above, it results that the world is a coherent ensemble of either inseparable identities or existential probabilities of identities.

The dynamics and processes of the sonorous art phenomena, in our case the conditions offered by a certain sonorous conception in its "interior" for the evolutionary path in the formation of a new sonorous conception, resemble rather ratios of uncertainties than logical ratios. The quantum level of knowledge is not accessible to knowledge-based instruments due to too many probabilities.

Until the beginning of the 20<sup>th</sup> century, the world was studied mechanistically. On the basis of Newton's concepts, the laws of matter, movement and forces were formed. On the basis of Maxwell's conceptions, the equations of the electromagnetic field were written. With the discovery of radioactivity, the subatomic level is penetrated. The observations made, no longer conformed to the laws of physics valid until then. Waiting for the particles to travel with a force resulting from the multiplication of their mass and acceleration, the researchers had the surprise of having "revealed" a universe of electrical interactions between presence and manifestations, predictable only with the help of quantum mechanics. Thus, determinism was replaced by non-determinism, specific to human psychism and sonorous art, due to the involvement of the human factor. Music is produced by the non-deterministic human psyche. Applying then the rationale of the "old" logic, how could a world of material certitudes, in which "materialistic and logical philosophy" function, let us discern it with instruments belonging to the world of uncertainties? How can be analyzed the multitude of behavioral study objects, of mental and emotional life of the creative and interpreting musicians be analyzed using the classical methodology? As such, the emergence of a new thinking logic becomes imperative.

In the nucleus, physicist Fritjof Capra notices only the tendencies to exist, no longer noticing permanent physical substance. According to the Austrian researcher, matter no longer exists, in the way this term was understood in the 19<sup>th</sup>-century sciences.

**Positions *pro***

Other researchers (Hennion 2003), on the contrary, are branching off their potential for knowledge towards the creative extensions of interdisciplinary, adventuring with good aesthetic sense and intellectual ease in areas very different from music, navigating the search for connections. According to sociologist Antoine Hennion, art can be subjected to social investigation or sociological analysis, meaning to the scientific methodology.

In philosophy, as well as in the fields of science found as an array of action outside the music and in the opposite sciences, there was found a structural congruence with music. A certain order found outside the music would be involved in it. Also, a certain order in music would be found in the fields outside itself. Composer, musical critic and American philosopher Charles Seeger "sees" a correlation between the structure of music and the natural structures outside it (trad. n.): "The intrinsic order of music has been found outside of it, or a certain order, extrinsic to the music found in it" (Seeger 1960, 224).

In conclusion, for the reasons given, the interpretation of the reality of art with the help of an apparatus of logic already known is at risk if not for erroneous formulations, at least for revealing incomplete aspects of an undisclosed, only intuited complexity. Noting the possibility of musical language to be modeled, Roger Dannenberg, Peter Desain and Henkjan Honing (the latter being a professor of music cognition in the Faculty of Humanities and the Faculty of Sciences at the University of Amsterdam) talk about the invitation that music extends to the formalizing descriptions. In their view, there are obviously many numerical reports in the structure of a music, and also there is music's resort to representing a geometric form, not necessarily musical (Dannenberg, Desain & Honing 1997, 271-315).

**CONCLUSIONS**

The intersection of some elements of the musical language with the tools of logical thinking results in quite a few common points. The musical creation in its inspirational allure descends from the abstract heights of archetypal encodings to be materialized in concrete morphology and syntax. The musical ideas on paper, when they receive a body of meanings, have already configured the appropriate language according to the compositional strategy. So when we use a musical language, it is self-evident that we also use the scientific extramusical ramifications or those of other arts.

There is a cognitive operational unit covering all fields of knowledge (eg, operations: identity, similarity, difference, personalization/generalization, impulse-development-degeneration, structure or genesis/destructuring or disappearance, generative succession, continuity, jump, accumulation, inclusion/exclusion, adaptation, transubstantiality, Yin/Yang duality in music, etc.).

Such an interdisciplinary study allows the realization of serious analogies and introspections. On the one hand, any chapter of logic can be introduced as an analogous analysis of the music/logic interdisciplinarity. On the other hand, such a "lens" of reasoning allows us to inspect, to observe, to investigate and, finally, to conclude by making predictions. Music would reveal itself from unknown sides as long as such a method would subject sound phenomena and processes to interdisciplinary testing.

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