MUSICA THEORICA 2024, V. 9.1
SCIENTIFIC ARTICLE
10.52930/mt.v9i1.291
Submission date: 08/04/2024
Acceptance date: 10/05/2024

Terminological Issues and Propositions in the Search for an Ontology of Harmonic Structures

Questões terminológicas e proposições na busca por uma ontologia de estruturas harmônicas

Marcus Alessi Bitencourt
Universidade Estadual de Maringá

Abstract: This article presents a fragment from a larger research with the intention of anticipating some of its main topics, which aim to assemble a pedagogical theoretical foundation for music harmony in the context of the globalized and diverse world of the 21st century. The research fragment presented discusses terminological issues and propositions for an ontological study of harmonic structures that concerns itself with the definition of what types of musical sound objects of definite pitch do exist, how many are there, which properties they possess and their musical consequences, all organized in a logical taxonomic system referred to by means of an adequate terminology. The text first establishes the need for such an ontology, and proceeds with a description of the terminological issues involved in a secondary term formation action, a subsequent renaming effort that is all the more challenging when dealing with a field with a huge lifetime such as music theory. The methodology used in the terminological recreation is then described, explaining its preference for terms that, regardless of their lexicographic origins and prevalence, are single-words that provide biunivocal association, that avoid ambiguity by synonymy and polysemy, that are self-explanatory, and that are of easy translation using same-lexeme words similar in graphical form. It is then given a brief summary of the structure of the created ontology, followed by the definitions, lexicographic origins, and neologism-creating derivational strategies for all its main proposed terms, including those to be used in the classifications of harmonic structures according to the criteria of cardinality, chirality, azimuth, triadic intrinsicality, monadic, triadic, and transpositional proclivities, limiting characteristics, and modalization, superset and subset relationships. To close the text, a schematic view of the organizational structure of the ontology is shown, together with its translation into three different languages.

Keywords: Music ontology. Music harmony. Music terminology. Costère theory. Set-theory.

Resumo: Este artigo apresenta um fragmento de uma pesquisa mais ampla, com a intenção de antecipar alguns de seus tópicos principais, que visam montar um corpo teórico pedagógico para a Harmonia Musical no contexto do mundo globalizado e diverso do século 21. O fragmento de pesquisa apresentado discute questões terminológicas e proposições para um estudo ontológico de estruturas harmônicas que se preocupa com a definição de quais tipos de objetos musicais de altura definida existem, quantos deles existem, que propriedades eles possuem e quais as suas consequências musicais, tudo organizado em um sistema lógico taxonômico passível de ser referenciado por meio de terminologia adequada. O texto primeiro estabelece a necessidade de tal ontologia e procede com uma descrição da problemática terminológica envolvida em uma ação de formação secundária de termos, um esforço subsequente de nomeação que é ainda mais desafiador quando se lida com uma área tão longeva como a Teoria da Música. A metodologia usada na recriação terminológica é então descrita, tendo explicada a sua preferência por termos que, independentemente de suas origens lexicográficas e sua prevalência, são palavras únicas que providenciam associação biunívoca, que evitam ambiguidade por sinonímia e polissemia, são autoexplicativas e são de fácil tradução por meio de palavras de mesmo lexema similares em sua forma gráfica. É providenciado então um breve sumário da estrutura da ontologia criada, seguido das definições, origens lexicográficas e estratégias derivacionais de criação neológica para todos os termos principais nela propostos, incluindo aqueles para serem utilizados na classificação das estruturas harmônicas segundo os critérios de cardinalidade, quiralidade, azimute, intrinsecalidade triádica, proclividades monádica, triádica e transposicional, características limitantes e relações de modalização, de superconjuntos e subconjuntos. Como conclusão, é mostrado um diagrama esquemático da estrutura organizacional da ontologia, juntamente com sua tradução para três línguas diferentes.

Palavras-chave: Ontologia musical. Harmonia musical. Terminologia musical. Teoria de Costère. Teoria dos conjuntos.

* * *

1. Introduction

This article presents a fragment from a bigger theoretical work with the intention of anticipating to the general academic public some of its main concepts and topics. Built from a theoretical framework developed during more than twenty five years of investigation and pedagogical work, this larger research addresses the challenges of assembling a more appropriate theoretical foundation for the learning of music harmony in the 21st century, in a manner attuned to the context of a globalized world and to contemporaneity's musical and aesthetic directives, yet being reverent to two thousand years of Western music theory.

With music harmony being defined in this work as the discipline of study inside music theory that takes as object of study the musical use of sounds of definite pitch, this research is currently being formalized in the form of a comprehensive treatise organized in three volumes written according to the methodology of a logic-deductive system "in geometrical order", as in Baruch Spinoza's Ethics (1677). Its first book presents definitions, axioms and propositions, mental constructs and mathematical models that serve as grounds to the contents of the other two volumes, treating subjects which start with the very perceptual sensation of sounds of definite pitch and go through the investigation of the possible different interactions of such sounds and the descriptions of their consequential properties, studied in increasing levels of combinatorial complexity. This first book bestows to the other ones a series of key concepts for the comprehension of musical thought in the Western tradition, such as consonance and dissonance, tonicity, phonicity, tonal hierarchies and prototypes of harmonic constructs, but these concepts are nonetheless treated in a generalized and universalizing fashion, envisaging also the possibility of their application to the understanding of a multiplicity of non-Western harmonic conceptions. The second volume demonstrates how the infinite universe of agglomerates of sounds of definite pitch can be reduced to 351 basic harmonic prototypes (also known in the work as "harmonic structures"), and presents a detailed ontological study of their harmonic properties, shown in the form of a thesaurus[1] mediated and introduced by theoretical explanatory chapters. The third book applies the principles worked in the previous volumes in the formalization of a structural model for triadic tonality, blending the logical deductive system used in the work with a critical revision (or perhaps actually a Bloomsian "misreading") of the theoretical world of 19th-century dualist functional harmony.

The research fragment presented here discusses and presents some of the terminological issues and propositions that were created for the ontological study of harmonic structures present in the second book of the treatise.

[1] An experimental preview of the current version of this thesaurus can be viewed online at <*https://www.marcusalessi.com/site/en/thesaurus*>.

2. The Need for an Ontology of Harmonic Structures

Every field of study — music theory and harmony included, naturally — needs a specialized language to talk about its subjects, to refer to its concepts and their relationships. This language always includes a whole assortment of specific terms, known as "nomenclature", that is, an ensemble of names that in a systematic manner covers the objects relevant to the given subject (Dubois *et al.*, 2002, p. 327); these specific terms, when rigorously defined so that they can be used to designate the notions and concepts useful to the field of study, become the "terminology" of that field (Dubois *et al.*, 2002, p. 481). A good parcel of the terminology of a field of study ends up being organized in a hierarchical system of classification which establishes the manner in which the classified elements relate to each other, generally by means of an organization in classes, superclasses and subclasses of elements, and this set of ordered nomenclatures is known as the "taxonomy" of that field (Dubois *et al.*, 2002, p. 477). It is impossible to efficiently investigate a field of study without the recourse of this process of naming, defining and organizing concepts, as already remarked by 17th-century polymath Gottfried Leibniz:

> The art of ranking things in genera and species is of no small importance and very much assists our judgment as well as our memory. You know how much it matters in botany, not to mention animals and other substances, or again moral and notional entities as some call them. Order largely depends on it, and many good authors write in such a way that their whole account could be divided and subdivided according to a procedure related to genera and species. This helps one not merely to retain things, but also to find them. And those who have laid out all sorts of notions under certain headings or categories have done something very useful. (Leibniz 1996, p. 291-292).

This whole process of definition and organization of the objects of study of a field is the concern of "ontology", whose purpose is precisely to figure out what things exist in a specific application domain, as put by computer scientist John Florian Sowa (2000), a researcher of knowledge representation:

> The subject of ontology is the study of the categories of things that exist or may exist in some domain. The product of such a study, called an ontology, is a catalog of the types of things that are assumed to exist in a domain of interest *D* from the perspective of a person who uses a language *L* for the purpose of talking about *D*. The types in the ontology represent the predicates, word senses, or concept and relation types of the language *L* when used to discuss topics in the domain *D*. (Sowa 2000, p. 492).

It is an ontology, combined with logical reasoning, which gives rise to a language whose purpose is to "express relationships about the entities in the domain of interest" (Sowa 2000, p. 492). Sowa continues:

> An informal ontology may be specified by a catalog of types that are either undefined or defined only by statements in a natural language. A formal ontology is specified by a collection of names for concept and relation types organized in a partial ordering by the type-subtype relation. Formal ontologies are further distinguished by the way the subtypes are distinguished from their supertypes: an axiomatized ontology distinguishes subtypes by axioms and definitions stated in a formal language, such as logic or some computer-oriented notation that can be translated to logic; a prototype-based ontology distinguishes subtypes by a comparison with a typical member or prototype for each subtype. Large ontologies often use a mixture of definitional methods: formal axioms and definitions are used for the terms in mathematics, physics, and engineering; and prototypes are used for plants, animals, and common household items. (Sowa 2000, p. 493).

Back to our original subject, it is therefore no surprise that it is key to any theoretical work on music harmony the creation of an ontology aiming at the definition of what types of musical sound objects of definite pitch do exist, how many of them are there, which properties they possess, what musical consequences these properties yield and, of course, it will be best if all those elements are defined and organized in logical taxonomic systems and are referred to in language by means of an adequate and well-chosen terminology.

Music theory being a discipline of study with more than 2000 years of age, we will find that vast numbers of different ontologies have already been devised across the centuries by countless theorists to address the challenges of understanding harmonic structures; and some of these ontologies are even conflicting, given the difficult task of comprehending a living art form which is present in multiple contexts of many human collectivities, always in a constant flux of evolution. The 21st century furthermore presents the music harmony researcher with the grind of making sense of this ontological inheritance, of critically choosing what to maintain, what to discard, what to revise, and what to create anew, always of course considering the context of the human community whose music is under scrutiny, which, in this 21st century of ours, is often not a context of a singular community but of a complex global one. And it is in this unavoidable contemporary context that a new ontological proposition must take place, aware of its origins but trying to look ahead.

3. The Challenges of Secondary Term Formation

Because of this huge lifetime of the music theory field, in this search for renewed ontologies for music harmony we will be for the most part dealing not with what the terminologist Juan Sager (1990) calls "primary term formation" — that is, the very first time that concepts are named, which is a much more experimental and tentative action and thus a rather uncontrollable phenomenon —, but we will be dealing instead with what he calls "secondary term formation", which is a subsequent renaming effort, usually performed in response to critical revisions of the concepts of the field and done considerably in a more organized, engineered way, with well-defined guidelines that are informed by the knowledge of the previous terminological experiences and the subsequent developments of the field and, furthermore, are attuned to the need to provide adequate translation to other languages (Sager 1990, p. 80-81). This effort of nomenclature recasting has at its disposal three main options: the use of existing resources, the modification of existing resources, and the creation of new linguistic entities, that is, neologisms (Sager 1990, p. 71). Furthermore, the terminologist Eugen Wüster (2003) describes these existing resources as being formed by: a) patrimonial words, that is, words formed from the etymological forms and phonetical laws of the language of the terminologist; b) assimilated and recent borrowings, which are those adopted from a foreign language somewhat in the past and adapted to the language of the terminologist; c) ephemeral borrowings, which are words taken directly from a foreign language without orthographic adaptation; d) terms transferred from other fields or disciplines; and e) the use of acronyms and the use of words resultant from the application of abbreviations, contractions or truncations of other words (Wüster 2003, p. 75-76). In the creation of terminologies, Sager also remarks that it is extremely useful to prefer the use of internationalisms over autochthonous forms, a task which in the Western world is commonly accomplished by the use of words and word elements taken from Classical Latin and Greek (Sager 1990, p. 86). In this sense, Wüster explains that this preference shows itself to be extremely useful for the internationalization of the terminology, because it prioritizes the use of terms whose graphical forms end up more or less preserved in their multiple translations to other languages (Wüster 2003, p. 25).

Another very important aspect to have in mind in terminological creation is that the connection between a term and its related concept must ideally be

biunivocal, that is, one concept must be bound to only one single term, and vice-versa (Wüster 2003, p. 137), avoiding either the occurrence of having multiple words for one same concept — what is known as synonymy —, or the occurrence of ambiguities in the form of polysemy — which is the property of a single linguistic sign to have multiple meanings (Dubois *et al.*, 2002, p. 369) —, and in the form of homonymy — which is the phonic or graphical similitude (homophony and homography, respectively) of two words which do not have the same meaning (Dubois *et al.*, 2002, p. 234). Although occurrences of synonymy, polysemy and homonymy do play an important part both in colloquial and formal languages, being sometimes even highly desirable and useful in those cases, nonetheless in specialized technical languages these occurrences can be the source of harmful confusion and useless mnemonic complications and should therefore be avoided, even if only ideally as a directive which is known to be not always attainable (Wüster 2003, p. 137).

As an example of a term-creating choice that creates confusion by means of undesirable polysemy, we can mention the act of overriding the meaning of a term already largely used in the field, an action most certainly taken in good faith in the spirit of prioritizing the use of existing resources, but which generates problems the sharper and more extensive the override is and the more present and strongly used the term in question is in the history of that field's technical language. In music theory we can see an example of such an unfortunate renaming action in Vincent D'Indy's *"Cours de Composition Musicale"* (1912) with his definition of the term "dominant", that he associates with the major triad on the fifth degree in the major mode and also with the minor triad on the fourth degree in the minor mode (D'Indy 1912, p. 110), which subverts the usual time-tested meaning practiced until today in the theoretical literature at least since Jean-Philippe Rameau's *Traité* in the 18th century (Rameau 1722, p. 56). The notion of a dominant of the minor mode brought by D'Indy, which springs from the dualist conception of the minor mode as an inverted, upside-down version of the major mode, could be better put forth not by overriding the meaning of an ancient, already largely used ubiquitous term, but perhaps by creating an altogether new term, such as the "regnant" one freshly coined for the same purpose — and hence more successfully — by Arthur von Oettingen (1913, p. 47).

Polysemy can also be caused by the coexistence of different uses for a term that was multiply defined in different theoretical contexts throughout history. An example of this problem in music theory occurs in the usage of the term "inversion", which according to the context serves to denote either the complementarity to the octave of two intervals, the rotations of the notes of a triad in the bass, or the reflection of an interval pattern about an axis of symmetry. This inconvenience could of course be solved by attributing a new single and different name for each single different conceptual idea — such as Howard Hanson's "involution" term borrowed from the mathematics field lexicon for the reflective kind of inversion (Hanson 1960, p. 17) — but this would be doubtlessly done at the expense of an older usage which may be deeply rooted in the field.

With all these issues in mind, the terminology creation action undertaken during this research was conducted with a certain number of directives, which will be stated next.

First: the wider the usage of a legacy terminology is, the more it should be preserved in the revised ontology, specially if the terms are not prone to giving rise to polysemy by multiple historical usage and in those cases where the concepts they point at are not having their theoretical boundaries redefined or are suffering just a mild amount of override. Sharper definition overrides of ubiquitous legacy terms will by necessity require their substitution.

Second: more obscure legacy terms taken from the history of the music theory field can be rescued from oblivion if their biunivocal association to their respective concepts is deemed to be clearer and more advantageous to the ontological need at hand.

Third: if a concept has not been adequately named by an entry in the lexicons of either the common general language or the technical language of the music theory field, common or obscure, a term can be borrowed by analogy from the lexicon of another field of study or, alternatively, a neologism can be invented by applying the rules of morphological derivation — that is, the process in linguistics of forming a new word from an existing word, often by adding a prefix or suffix (Kroeger 2005, p. 247), specially with the usage of Latin and Greek word components.

Fourth: preference should be given to terms that are self-explanatory, that is, to terms whose meaning can already be hinted at by the inspection of their

own word components (as in the words "clockwise" and "asymmetrical"), and to terms that preserve their main graphical form in translations between the English, Portuguese and French languages, which are the main languages elected for use in this research project.

Therefore, for the terminological efforts of this research, regardless of its lexicographic origins and prevalence, a word will be said to meet the standards for suitableness of adoption as a name in the ontology if it provides biunivocal association and if it is a single, self-explanatory term that allows for easy translation using words similar in graphical form. Such names will be referred hereafter in this text as "suitable terms".

4. Morphological Derivation: Words and the Logic of their Construction

Since readers of music theory texts are not necessarily well-versed in concepts of linguistics, it may be convenient at this point to introduce some basic general knowledge regarding the structure of words and the process of morphological derivation.

A "word" in linguistics is defined as being a significant linguistic element made out of one or several non-segmentable distinctive traits, or "phonemes" (Dubois *et al.*, 2002, p. 312, p. 359). The smallest meaningful groups of phonemes in the utterance of a word are called "morphemes", and those can be said to be "free", when they have the possibility of occurring as complete words, or "bound", when they do not; furthermore, there are two types of morphemes: "roots", usually free morphemes that form the main core of a word, and "affixes", bound morphemes which are added on to a root and that modify its meaning in a consistent way (Kroeger 2005, p. 12-14).

The process of creating words by joining affixes to roots, known as "affixation", is said to be of the "derivational type", when the affixation process creates a new word out of an old one, or of the "inflectional type", when it just creates grammatical variants of same word, such as gender, plural, or declined versions of that word (Kroeger 2005, p. 247). According to its morphemic composition, a word can be a "root word", when it is comprised by one root and no affixes, a "compound word", when it is comprised of two roots and perhaps

some affixes, or a "derived word", when it is comprised of one root with some derivational affixes (Wüster 2003, p. 73).

All the grammatical variants by inflectional affixation of a word are collectively known as a "lexeme" and, as such, all the variant words of the same lexeme have in common a "stem", that is, the union of the roots of that word together with only its derivational affixes, excluding its inflectional ones (Kroeger 2005, p. 247-248). In the collective listing of all the words which are used by an author, by a science or by a field of study, known as the "lexicon" of that author, science or field (Dubois *et al.*, 2002, p. 282), what each entry refers to is therefore to a single "lexeme", or "lexical entry" (Kroeger 2005, p. 66).

5. Description of the Proposal for an Ontology of Harmonic Structures

Basically, as we have seen earlier, an ontology of harmonic structures serves the purpose of defining and naming with an adequate and well-chosen terminology what types of musical sound objects of definite pitch do exist, how many of them are there, which properties they possess, and what musical consequences these properties yield. The main models used in this ontological research were the classification methodologies presented in the pioneering theoretical works by Howard Hanson (1960), by Allen Forte (1973) and, most especially, in Edmond Costère's *"Lois et Styles des Harmonies Musicales"* (1954). Although not very known outside a very specialized niche circle, Costère — a pseudonym used by Edouard Coester (1905-2001) to separate his theoretical work in music from his professional career in law as magistrate (Ellard 1973, p. 2) — is in particular the author of an extremely ingenious and useful taxonomic work for harmonic structures, which constitutes an important part of the basic skeleton of this present ontological proposal.

5.1. The Reduction of the Infinite Harmonic Universe to 351 Prototypes

The ontology of harmonic structures starts by giving the name "note" to the main object of its study, namely the sounds of definite pitch, making obvious use of legacy terminology — it is a suitable word by its derivation from the Latin *"nota"*, meaning "mark", "sign" (Vaan 2008, p. 414) — and in special following

and taking advantage of Pierre Schaeffer's generalized definition for his "N" (*note de musique*) sound object: a balanced type of sound object of fixed tonic mass (Schaeffer 1966, p. 446). After this core definition, the investigation of the universe of different possible combinations of notes — which is at first infinite in number and therefore inscrutable as such — becomes manageable by means of the application of three equivalence notions: a) enharmonic equivalence, which is the notion that notes very close in pitch can be considered to be equivalent; b) octave equivalence, which is the notion that notes of pitches related by simple or compound perfect octaves can be considered to be equivalent; and c) transpositional equivalence, or rather the idea that the harmonic properties inherent to a specific arrangement of notes depend not on the actual pitches of the notes but rather on the exact configuration of musical intervals formed between them, which has as consequence that transpositions of the same intervallic configuration should be considered equivalent in terms of their harmonic properties.

From enharmonic equivalence it is formed the notion of a "metanote", a created suitable neologism by affixation of the Greek morpheme *"meta"* — meaning "in quest or pursuit of" (Morwood; Taylor 2002, p. 209) — denoting a note comprehended as a theoretical imaginary representative of several different notes to which it is enharmonically equivalent. The purpose of this concept is to allow the postulation of an equally-spaced temperament system, not to be necessarily used in musical terms but to be used mostly as a conceptual tool which can, in a simplified and symmetrical manner, provide a finite collection of notes able to represent, within an amount of mistuning acceptable to the human ear, all the first intervals present in the harmonic series up to its 10th harmonic — in the treatise it is demonstrated that the most economical and advantageous temperament system for this is the one with 12 equally-spaced metanotes to an octave, a concept of course already known for centuries to Western and Eastern theorists alike (Barbour 1951, p. 55). The interval between two metanotes is therefore a "metainterval", an interval whose size is also not necessarily to be directly used in music but it is to be used as the imaginary representation of a range of just intervals of very similar size to which it is enharmonically equivalent.

From octave equivalence it is formed the notion termed in the ontology "chroma", using a legacy word from the psychoacoustics field lexicon (used here

as an ephemeral borrowing) coined by biophysicist Albert Bachem (1937, p. 147), which is the representation of all notes that are equivalent by octave relationship, substituting with a single word the more widespread technical term "pitch class" present in American set theory (Forte 1973, p.1), which does not translate nicely to Portuguese (the expression ends up being the rather awkward *"classe de alturas"*). In the same vein as described earlier, it follows in the ontology that there must be the concept of a "metachroma", another created neologism meaning an imaginary chroma used as a conceptual tool to represent all chromas which are enharmonically equivalent to it. It is this metachroma concept that allows the infinite universe of combinations of notes to be reduced to only 4095 combinations of metachromas (that is, 2^{12} minus the empty set, considering the temperament of 12 equally-spaced metanotes to an octave). Each of the 12 metachromas is to be indicated by a number from 0 to 11 as in American set-theory (with the chroma relative to the note C bearing the number 0), but, in order to avoid numbers with two digits, the number 10 is to be substituted by the letter "d" (taken from the Latin *"decem"*), and the number 11 is to be substituted by the letter "u" (taken from the Latin *"undecim"*).

From transpositional equivalence we create the notion termed in the ontology "conformation", a legacy word taken from the general lexicon meaning a "particular form, shape, or structure" (Davidson 1903, p. 196). This word is preferred here because it substitutes with a suitable word the widespread technical terms "prime form" or "Tn type" used in American set-theory, for example (Rahn 1980, p. 75), and also the odd French technical term *"échellonnement"* (Costère 1954, p. 62), which does not translate suitably to English using the same lexeme. By conformation it is understood the unique configuration of metaintervals which represents all groups of metachromas which are equivalent by transposition to it. As such, using metachromas belonging to the equal temperament of 12 notes to the octave, there are only 351 different conformations of metachromas (352 minus the empty set), a number which can be determined by the application of the so-called enumeration theorem by mathematician György Pólya (Weisstein 1999, p. 1395). The 351 conformations are indicated in the treatise by means of using both the notation used in American set-theory — in the convention adopted by Rahn (1980) — and a revised version of Costère's *"nombre représentatif"* (Costère 1954, p. 64), making use of the same normative ordering as the one used in American set-theory (Forte

1973, p. 4). Thus, the equal-tempered metaversion of the conformation is indicated simply by its set-theory label and the different real-world tuning variants of that conformation can be indicated whenever necessary by adding superscripts (to indicate a heightening in tuning) and subscripts (to indicate a lowering in tuning) to the label numbers. The actual amount of tuning variation is measured in the treatise using as unit the interval of proportion $2^{1/612}$ — which is approximately the interval used to temper a just perfect fifth of ratio 3/2 to the tempered perfect fifth of proportion $2^{7/12}$ (or about 2 cents of a semitone). This unit is termed a "schisma", taking advantage of an ancient legacy word from the music field lexicon with just a slight override of its historical definition. Each tuning variant of a conformation is termed in the ontology an "allomorph" of that conformation, borrowing a suitable general lexicon entry made out of Greek morphemes — *allos*, other; and *morphē*, form — which is the name given to the different forms assumed by the same substance or thing (Thatcher; McQueen 1980, p. 23). As an example of such allomorphs, for the conformation labeled (05), which is the normative ordering respective to the tempered metainterval of a perfect fifth of proportion $2^{7/12}$, its just intonation allomorph of ratio 3/2 is labeled (05_1); for the conformation labeled (06), which is respective to the tempered metainterval of a tritone of proportion $2^{6/12}$, its just intonation allomorph of ratio 7/5 is labeled (06_9), and its other just intonation allomorph of ratio 10/7 is labeled (06^9).

Each transposition of a conformation is termed in the ontology a "species" of that conformation, borrowing a suitable and very well-known term used in the zoology lexicon — derived from the Latin *"speciēs"*, a"view", "aspect", "appearance" (Vaan 2008, p. 578) —, in substitution of the term "pitch class set" used in American set-theory (Forte 1973, p. 1) — for it translates cumbersomely to Portuguese as *"conjunto de classes de alturas"* — and in substitution of the term *"gamme"* used by Costère (1952, p. 61) — because its direct same-lexeme translations to English and Portuguese ("gamut" and *"gama"*, respectively) do not retain the exact denotation and create adverse polysemy by overriding too sharply the meaning of a synonym of the ubiquitous term "scale" from the music field lexicon. Each of the 12 species of a conformation is indicated by the first metachroma of its normative form followed by a comma, both placed at the left of the first parenthesis of the conformation label. Thus, the F major triad is indicated as the fifth species of conformation (047), bearing therefore the label

5, (047). A species can also have allomorphs and these are indicated as well by subscripts or superscripts placed this time on the number indicating the species. Thus, a just intonation major triad built on a note of pitch 355 Hz (an F4 note 14 schismas higher) will belong to the allomorphic conformation species bearing the label 5^{14}, ($04_7 7^1$).

In American set-theory, it is also common to argue that it is possible to reduce the universe of harmonic structures even further by means of positing an inversional equivalence concept (Forte 1973, p. 7) and also an equivalence of intervallic content, or Z-relation (Forte 1973, p. 21). This present ontology, agreeing with the arguments laid out by Costère (1954), rejects these two concepts as being relationships of equivalence, although it does recognize them as meaningful types of relationships. The main reason for this is that conformations related to each other by such relationships differ diametrically in terms of their phonicity and tonicity (Bittencourt 2016, p. 418), which are harmonic properties not investigated or treated either in the texts by Costère nor in those by the set-theorists, as will be discussed later on in this text.

5.2. Classification According to the Criterion of Cardinality

By "cardinality" it is understood in mathematics the number of elements of a given set (Weisstein 1999, p. 189). Thus, if a conformation has from 1 to 12 different metachromas it will be classified respectively as a monad, dyad, trichord, tetrachord, pentachord, hexachord, septachord, octachord, nonachord, decachord, undecachord, dodecachord (Rahn 1980, p. 74). Here the terminological decision was to just keep words commonly used for this type of classification, which are taken from the historical music field lexicon and are already suitable terms constructed out of Greek or Latin morphemes.

5.3. Classification According to the Criterion of Chirality

"Chirality" is the property respective to something that is "chiral", both well-known terms from the chemistry field lexicon introduced by Lord Kelvin denoting the property possessed by a geometrical structure which cannot be brought to coincide with its mirror image (Kelvin 1894, p. 27) — these words take

advantage of the Greek root *"kheir"*, "hand" (Onions 1966, p. 170), perhaps the most familiar known object possessing chirality.

As such, a conformation is to be classified in the ontology as "chiral" if the inversional reflection of its metaintervallic configuration can't be brought to coincide to its own configuration, and thus the conformation is said to invert reflectively to another different conformation. On the other hand, a conformation is classified as "achiral" (or "symmetrical", if we prefer to name things by what they are, instead of by what they are not) if the inversional reflection of its metaintervallic configuration can indeed be brought to coincide to its own configuration, and thus the conformation is said to invert reflectively to itself.

Of the 351 conformations, 95 of them are achiral and 256 are chiral, these last ones being naturally arranged in 128 pairs of inversionally related conformations. Each pair of chiral conformations are called in the ontology "enantiomers" — a suitable word using the Greek morphemes *"enantíos"*, meaning "contrary", "reverse" (Morwood; Taylor 2002, p. 111), and *"méros"*, "part" (Morwood; Taylor 2002, p. 208) —, borrowing another common term from the chemistry field lexicon used to name each of the elements of a pair of structures which are non-superimposable mirror images of each other (Bynum; Browne; Porter 1981, p. 218). In the ontology, an enantiomer pair of conformations is indicated with both their labels placed inside brackets, with the most normative first. Thus, the pair of conformations relating to the minor and major triads is to be indicated as [(037)(047)].

It must be mentioned here that there is also a special similarity relationship recognized between different conformations that have the same kind and number of intervals but are not enantiomers of each other, a relationship that American set-theory denominates "Z-relation" (Forte 1973, p. 21) — which clearly is not a self-explaining word, with the "Z" standing for "zygotic" (Schuijer 2008, p. 98), a word from the biology lexicon related to "zygote", which denotes the product of the fusion of two gametes (Thatcher; Mcqueen 1980, p. 972). Howard Hanson also treated this topic, calling those conformations "isomeric sonorities" (Hanson 1960, p. 22), in a clear analogy with the term "isomer" from the chemistry field lexicon, in which it names the relationship between "compounds with the same kind and same number of atoms but differing in their arrangement" (Bynum; Browne; Porter 1981, p. 218). The problem here is that this analogy may not be terminologically perfect, for in

chemistry enantiomer molecules — whose name we also borrowed into the ontology to denominate conformations related by reflective inversion — are also a subtype of isomeric molecules called stereoisomers, with the Z-relation property being more akin to the isomer subtype properly called a structural isomer. Thus, in order not to use in the ontology either a rather imperfect borrowing analogy ("isomer") or a term with two words ("structural isomer"), the Z-relation term is substituted by a suitable older term from the chemical field lexicon used for structural isomers: "metamer" (Bynum; Browne; Porter 1981, p. 218).

Returning to the achiral conformations, their symmetrical nature also entails that they possess one or more axes of symmetry, "axis" being a well-known term taken from the general lexicon, suitable to be kept in the ontology for its derivation from the roots *"axis"* and *"áxōn"* from Latin and Greek, respectively, both meaning "pivot" (Onions 1966, p. 66). Every symmetrical conformation has at least one axis of symmetry, which cuts through two axial chromas at the distance of a tritone (Costère 1954, p. 73). Thus, the ontology includes some subtypes for symmetrical conformations, according to the nature of their axes — a property which will be known by the derived word "axiality" —, taking as starting point the classificatory lead by Costère (1954, p. 72). Here, the criteria to account for are three: intrinsicality of the axes to the temperament grid used, intrinsicality of the axes to the conformation, and cardinality of axes, with each axial chroma counting as one axis.

Regarding intrinsicality to the temperament grid used, except in two highly symmetrical cases that will be seen later — conformations (0369) and the dodecachord, which oddly have multiple axes half belonging and half not belonging to the temperament grid —, for all other remaining conformations either all axes are intrinsic to the temperament (that is, they belong to it) or all are extrinsic (that is, they do not belong to it). If the conformation's axes are intrinsic to the temperament grid, it will be classified according to whether the axes are intrinsic to the conformation and whether there is one pair of tritonal axes or more than one pair. The terms chosen for the ontology are guaranteed suitable created neologisms constructed by adding to the root "axis" the Latin morphemes *"intra"* — "on the inside" (Onions 1966, p. 482) —, *"extra"* — "outside" (Onions 1966, p. 339) —, *"bi"* — "twice" (Onions 1966, p. 92) —, *"multi"* — "many" (Onions 1966, p. 596) —, and *"ambi"* — "both" (Onions 1966, p. 30) —

, which in most cases is exchanged by the equivalent Greek morpheme *"amphi"* — "on both sides" (Morwood; Taylor 2002, p. 20) —, either to avoid an awkward consonantal encounter with the *"bi"* morpheme, or for the sake of derivational parallelism with other terms in which that exchange happens. Hence, the terms created are: "intrabiaxial" (one pair of tritonal axes intrinsic to the temperament grid, all intrinsic to the conformation), "extrabiaxial" (one pair of tritonal axes intrinsic to the temperament grid, all extrinsic to the conformation), "amphibiaxial" (one pair of tritonal axes intrinsic to the temperament grid, one of them intrinsic to the conformation, the other extrinsic), "intramultiaxial" (more than one pair of tritonal axes intrinsic to the temperament grid, all intrinsic to the conformation), "extramultiaxial" (more than one pair of tritonal axes intrinsic to the temperament grid, all extrinsic to the conformation), and "amphimultiaxial" (more than one pair of tritonal axes intrinsic to the temperament grid, some of them intrinsic to the conformation, some extrinsic). These terms serve to extend, clarify and substitute the French terms *"symétrie médiane"* and *"à note médiane"* used by Costère (Costère 1954, p. 72-75), which were deemed to be not self-explanatory enough.

If all the conformation's axes are extrinsic to the temperament grid, they are also evidently extrinsic to the conformation and as such it will be classified only according to whether there is one pair of tritonal axes or more than one pair. The suitable terms here chosen for the ontology are also created neologisms, this time constructed by affixation of the Latin morpheme *"apo"* — "removal", "departure" (Onions 1966, p. 42) —, in addition to the repertoire of morphemes already listed. Hence, the terms created are: "biapoaxial" (one pair of tritonal axes extrinsic to the temperament grid), and "multiapoaxial" (more than one pair of such tritonal axes). These terms serve to substitute and improve upon the French term *"symétrie intercalaire"* used for the same concept by Costère (Costère 1954, p. 72), and were chosen in the ontology for the sake of self-explanatory constructive parallelism with the other terms adopted for these subtypes.

Regarding the only two odd cases of conformations mentioned earlier — (0369) and the dodecachord — that bear a multiplicity of axes that are both intrinsic and extrinsic to the temperament grid, those will be classified under the term "heteromultiaxial", making use of the greek morpheme *"héteros"*, meaning "different, of another kind, at variance" (Morwood; Taylor 2002, p. 140).

Fig. 1 shows examples of conformations for each of those different types of axiality, making use of a representation in clock-face dial format to better evidence the particular specularity of each configuration about its axes of symmetry.

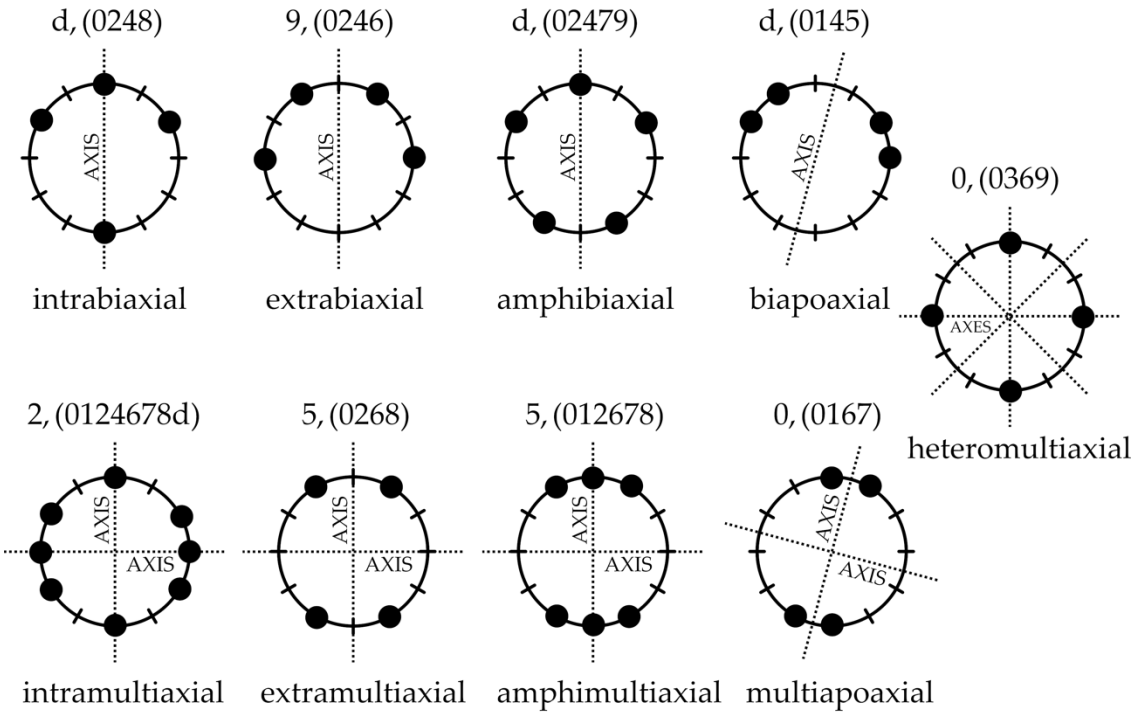

Figure 1: Examples of conformations for all types of axiality

5.4. Classification According to the Criterion of Azimuth

The next criterion for classification to be seen in the ontology is one not developed in any of the theoretical models mentioned earlier, being an original contribution of mine to it, one that springs directly from Arthur von Oettingen's late 19th-century dualist harmonic theory of tonicity and phonicity (Oettingen 1913, p. 32), but extended beyond the context of triadic tonality.

The concept of "tonicity" — a rather little-known entry from the music field lexicon coined by Oettingen (1913, p. 32) — is taken in the ontology very much in its original sense meaning the measurement of the extent to which a conformation contains metachromas whose overtones are equivalent to the overtones of a single metachroma, known as the "root" of that conformation, and

which thus acts as a single common fundamental tone for it. Thus, the "root" of a conformation — this word being an extremely common and therefore rather inescapable term taken from the music field lexicon — is defined in the ontology as the metachroma location, either intrinsic or extrinsic to the conformation, whose first harmonic is equivalent to the best candidate for a common fundamental tone for the constituent elements of that conformation as a group (Bittencourt 2016, p. 406).

The concept of "phonicity" — another rather obscure entry from the music field lexicon coined by Oettingen (1913, p. 33) — is taken in the ontology also in its original sense meaning the measurement of the extent to which the conformation contains metachromas that are equivalent to different fundamental tones bound by a single common overtone, known as the "vertex" of that conformation — a term borrowed in the ontology from the geometry field lexicon as a substitute for Oettingen's "phonic overtone" term (Oettingen 1913, p. 33). Thus, the vertex of a conformation is defined in the ontology as the metachroma location, also either intrinsic or extrinsic to the conformation, whose first harmonic is equivalent to the best candidate for a common overtone for the constituent elements of that conformation as a group (Bittencourt 2016, p. 407).

Tonicity and phonicity are in the ontology shown to be the cause in triadic tonality to that which is commonly known as the modal gender notions associated to the major and minor triads. Moreover, these properties are shown to be generalizable properties extensible beyond perfect triads to all possible conformations (Bittencourt 2016, p. 425).

In the ontology, the "azimuth" of a conformation is the measurement of its bias towards a tonic nature — when its roots are stronger than its vertices — or towards a phonic nature — when its vertices are stronger than its roots — (Bittencourt 2016, p. 408). Borrowed from the astronomy field lexicon — in which it names the measurement of the horizontal arc between a point of reference and the vertical projection towards the horizon of a celestial body (Thatcher; McQueen 1980, p. 59) —, this term is suitable by its derivation from the Arabic morpheme *"assumuth"*, "way", "path". Azimuths of conformations of tonic nature by convention are positive in value and those of conformations of phonic nature are negative, with the maximum absolute values being set to +90° and −90°, which incidentally are the values for the major and minor triads, respectively.

Conformations which bear the same amount of tonicity and phonicity have therefore a null azimuth and are said in the ontology to be of "amphibolic" nature, a term also imported from Oettingen's terminology (Oettingen 1913, p. 34), taken in the same sense; this suitable word is also present in several technical lexicons, being derived from the Greek morphemes *"amphi"*, "on both sides" (as already seen earlier), and *"ballein"*, "to throw" (Davidson 1903, p. 28). In this sense, the term amphibolic seems very adequate to name such conformations, for they are not neutral in terms of tonicity and phonicity, they actually have both those properties in equal strength.

Of the 351 conformations, 155 are of amphibolic nature, 98 are of tonic and 98 are of phonic nature. All 95 achiral conformations are of amphibolic nature due to their symmetrical structures, which cause their tonicities and phonicities to have the exact same intensity (Bittencourt 2016, p. 418). Contrariwise, due to its asymmetrical structure, if a chiral conformation has a bias towards a tonic nature, then its enantiomer will have instead a bias of equal strength but opposite direction towards a phonic nature, which corroborates for the thesis of the nonequivalence of enantiomer pairs mentioned earlier in this text and also serves to further clarify the nature of the antipodal opposition relationship held between them.

From the 128 pairs of chiral conformations, 98 pairs have non-null azimuths, being therefore comprised of one tonic (major) conformation and one corresponding phonic (minor) enantiomer twin, both with symmetrically opposed equal azimuth absolute values (Bittencourt 2016, p. 418). The remaining 30 pairs of chiral conformations are comprised of a mixture of an achiral subset (which is therefore amphibolic) added to other metachromas which, while introducing chirality to the resulting conformation, do so without upsetting the original amphibolic nature of their achiral companion subset (Bittencourt 2016, p. 423).

5.5. Classification According to the Criterion of Triadic Intrinsicality

The next criterion for classification is the acknowledgement of the existence or not of perfect triads that are intrinsic to the conformation. At this point, the terminology proposed by Costère is very interesting and pertinent but conceptually problematic, for he uses the terms "tonal", "neutral", and "atonal"

for denoting conformations that are, respectively, inclusive of perfect triads, not inclusive of perfect triads but nonetheless inclusive of perfect fifths, not inclusive of perfect triads nor fifths (Costère 1954, p. 78-80). The idea here is that conformations that have intrinsic perfect triads — or, in their absence, have intrinsicality of their strongest intervallic component, perfect fifths — do have special stability and affinity harmonic properties, which is an important consideration with very interesting theoretical ramifications. Nonetheless, Costère's preference was to directly associate the presence or compositional use of triads and their stability to the concept of a "tonal style", with the absence or compositional dismissal of perfect fifths or triads being associated to the concept of an "atonal style" (Costère 1954, p. 180). This entails the adoption of a specific rather narrow definition of tonality, one based exclusively on the intrinsicality of perfect fifths or triads, which is indeed a possible choice but one deemed to be counterproductive in this ontology, considering its aim of constructing a generalized version of the musical use of notes. In the ontology, the decision taken was to focus the definition of the concept of tonality in the acknowledgement of the existence of gravitational forces acting between musical notes — a concept developed by Costère to which he used the name "polarity" (Costère 1954, p. 183), which will be better described later on in this text —, and, although these forces do demonstrably operate best when perfect fifths or triads are involved, they nonetheless operate regardless of their presence. The term envisioned in the ontology for this enlarged concept of tonality is "architonality", denoting a primeval generalized tonality, a created neologism made by incorporation of the well-known morpheme derived from the Latin *"archi"* and the Greek *"arkhi"* — meaning "beginning", "reign" —, as well as the Greek *"árkhos"* — meaning "guide", "head" — (Onions 1966, p. 48). As such, Costère's specific narrower definition of tonality does nonetheless survive in the ontology as a subtype concept termed "triadic tonality".

That being so, in the ontology the classification of conformations according to the criterion of intrinsicality of perfects triads retains those three categories posited by Costère — "tonal", "neutral", and "atonal" — but under the different denominations of "triadic", "diapentic", and "atriadic", respectively. The words triadic and atriadic emphasize the focus of attention on the intrinsicality or not of triads to the conformation, but without committing this emphasis as the crux to the definition of tonality or atonality. The term

"diapentic" — which substitutes for Costère's "neutral" category — is a suitable neologism created by adjectivizing the word "diapente", a classical term taken from the music field lexicon, which is the ancient Greek name for the interval of the perfect fifth (Brenet 1926, p. 116).

Triadic conformations will also yield subtypes in the ontology, this time with the terminology being borrowed directly from Costère's work. These subtypes are "major" — when the intrinsic major triads outweigh in importance the intrinsic minor triads —, "minor" — when the intrinsic minor triads outweigh in importance the intrinsic major triads —, "major-minor" — when the intrinsic major triads are equal in importance to the intrinsic minor triads —, and "binary" — when the conformation is mainly centered on a combination consisting of both intrinsic minor and major triads on the same root — (Costère 1954, p. 80). Diapentic conformations yield the subtypes "major", "minor", and "major-minor", in the same sense used in the triadic ones, but considering the major or minor propensity of their intrinsic perfect fifths.

Of the 351 conformations, 268 are triadic, 53 are diapentic, and only 30 are atriadic (Costère 1954, p. 78–80).

5.6. Classification According to the Criterion of Proclivity

The most original and intriguing contribution of Edmond Costère's work to music theory is his investigation of the currents of attractive forces believed to exist between musical notes, which create the bouts of harmonic tension and release responsible for directing the natural dynamic evolution of one sound to the next, as Costère himself puts it:

> In harmony, the law of tension is manifested by currents of attractive force, which tangle and untangle, from one sound to another, independent of any rhythmic or melodic thrust. If these forces concentrate on certain specific sounds of a sound entity, they can make it the harmonic center of gravity of this entity. They can therefore, depending on the location of this harmonic center of gravity relative to the entity, condition its stability or instability and direct its own harmonic dynamism (Costère 1954, p. 15, translation by the author).[2]

[2] In the original: "Dans l'harmonie, la loi de tension se manifeste par des courants de force attractive, qui se nouent et se dénouent, d'un son à l'autre, hors de toute poussée rythmique ou mélodique. Si ces forces se concentrent sur certains sons déterminés d'une entité sonore, elles

The concentration of these lines of gravitational forces toward specific chromas would in Costère's view turn these into what he denominated "poles of attraction". The mapping out of the location and intensity of these poles — a task which he accomplished by means of an ingenious mathematical model — became then the cornerstone of his theoretical thought and taxonomic efforts, being formalized by his *"Loi de l'Attraction Universelle"* (Costère 1954, p. 15), which establishes that sounds are propense to travel the shortest paths possible, measured in two dimensions: the realm of the harmonic series, and the realm of the smallest interval in the temperament grid used. Thus, given a specific group of chromas, Costère speaks of its "cardinal gravitation" — that is, the system of lines of attraction formed within that group that are directed towards individual chromas, either intrinsic or extrinsic to it —, he speaks of its "tonal gravitation" — that is, the system of lines of attraction formed within that group that are directed towards perfect triads, either intrinsic or extrinsic to it —, and he speaks of its "transpositional gravitation" — the system of lines of attraction formed within that group that are directed towards different transpositions of itself (Costère 1954, p. 41).

The present ontology effects a considerable revamping of that theory, reconstructing and recontextualizing its tenets and mathematical models to fit a larger theoretical system. This reconstruction included naturally also a terminological revision, which starts with the very term used to name the phenomenon of attraction, substituting the terms used by Costère — which veers in his texts between the words "gravitation", "attraction", "affinity", "polarity" — by the term "proclivity", a word taken from the general language lexicon meaning "propensity", "tendency", which is derived from the Latin word *"proclivitas"*, "inclination" (Thatcher; McQueen 1980, p. 662), and denotes just the right idea needed here, using a suitable word. As companion words to it, we have the adjective "proclive" — of same derivation and which denotes the quality of that which is impacted by proclivity, that is, that which has a natural tendency (Davidson 1903, p. 731) — and the noun "attractiveness" — a word borrowed from the general language lexicon which is also suitable due to its

---

peuvent en faire le centre de gravité harmonique de cette entité. Elles peuvent donc, selon l'emplacement de ce centre de gravité harmonique, relativement à l'entité, conditionner la stabilité, ou l'instabilité de celle-ci, et orienter son propre dynamisme harmonique" (Costère 1954, p. 15).

direct derivation from the Latin *"attractum"* (*"ad"*, "to", with *"traho"*, "to draw"), meaning "the quality of being attractive or engaging" (Thatcher; McQueen 1980, p. 54).

As such, a quick abridged explanation of the revised concept of proclivity used in the ontology is that the more referential to the same invariant pitch components two metachromas are, the more proclive they are to effect a motion from one to the other. In this sense, if a metachroma has a specific proclivity towards another metachroma, then the later, being the target of the first's proclivity, will have the intensity of that proclivity accrued in its attractiveness. Thus, in the context of a conformation, the attractiveness of a specific intrinsic or extrinsic metachroma is the measurement of how intensely it is the target of the proclivities of the intrinsic metachromas.

5.6.1. Classification According to the Criterion of Monadic Proclivity

In the ontology, those three types of gravitation posited by Costère and their ensuing taxonomy were mostly maintained, although with a substantial terminological revision and some few expansions. His first category, "cardinal gravitation", is denominated in the ontology "monadic proclivity", avoiding unnecessary conflict with the term "cardinality" and taking advantage of the term "monad" already used in the ontology for a conformation of cardinality 1, that is, a single metachroma. The conformation types posited for this type of proclivity use as classification criterion the "transitivity" of the conformation — this being a common and self-explanatory term borrowed into the ontology from the general language lexicon that is suitable due to its derivation from the Latin *"transīre"*, meaning "to pass over" (Onions 1966, p. 936-7). The transitivity of a conformation is the estimation of how proclive its metachromas are to flow towards locations outside itself. In this sense, a conformation that has a null transitivity is therefore a stable entity which tends to immobility; a conformation that has some degree of transitivity is an unstable entity which tends, according to the magnitude of its transitivity, to move elsewhere. The two ensuing classification categories, denominated by Costère *"gammes denses"* and *"gammes transitives"* (Costère 1954, p. 85), so to eschew rather imperfect analogies with weight and gravity, were in the ontology given the denominations "cislocative" and "translocative", respectively, terms borrowed from the linguistics field

lexicon in which they name types of linguistic units that indicate motions towards or away from, respectively, the deictic center, that is, the anchorage point of reference, most often the speaker (Guillaume; Koch 2021, p. 10). The suitability of those words is guaranteed by their derivation out of the Latin morphemes *"cis"* — meaning "before", "within", "on this side of" (Vaan 2008, p. 115) —, *"trans"* — meaning "across", "on the other side of" (Vaan 2008, p. 627) —, and *"locus"* — meaning "place" (Vaan 2008, p. 347).

Other classificatory types worked out by Costère that are still related to the investigation of monadic proclivity concern the strength and location of what is called in the ontology the "monadic poles" (or simply "poles") of the conformation — naturally, the intrinsic or extrinsic metachromas with the biggest accrued attractiveness in the context of that conformation —, a term adapted from the expression *"pôle cardinal"* by Costère (Costère 1954, p. 85), maintaining the word "pole", which is just perfectly suitable, being derived from the Latin *"polus"*, "end of an axis" (Onions 1966, p. 693).

At this point, the terminology used by Costère — which is rather opaque in self-explanatory meaning and at times overrides unfavorably the meaning of ubiquitous terms from the music field lexicon such as "cadential" or "tonic" — is substituted in the ontology by suitable neologisms that were systematically created by adding to the root "pole" the already listed repertoire of morphemes *"bi"*, *"multi"*, *"intra"*, *"extra"*, *"amphi"*, in addition to the very common Latin morphemes *"uni"* — "one" (Onions 1966, p. 960) — and *"sub"* — "under", "subordinate", "secondary" (Onions 1966, p. 879).

Thus, the type *"à pôle cardinal tonique"*, used by Costère to name the case in which all the conformation's poles are intrinsic to it (Costère 1954, p. 86), is substituted and expanded by the categorical terms "intraunipolar" or "intrabipolar" — for conformations that don't have extrinsic poles and, respectively, have only one intrinsic pole, or are achiral with only one pair of intrinsic poles —, and "intramultipolar" — for conformations that don't have extrinsic poles and are either chiral with more than one intrinsic pole, or achiral with more than one pair of intrinsic poles. The type *"à pôle cardinal extrinsèque"*, used by Costère to name the case in which all the conformation's poles are extrinsic to it (Costère 1954, p. 86), is substituted and expanded by the terms "extraunipolar" or "extrabipolar" — for conformations that don't have intrinsic poles and, respectively, have only one extrinsic pole, or are achiral with only one

pair of extrinsic poles —, and "extramultipolar" — for conformations that don't have intrinsic poles and are either chiral with more than one extrinsic pole, or achiral with more than one pair of extrinsic poles. The type *"à pôle cardinal équilibré"*, used by Costère to name the case in which the conformation's poles are both intrinsic and extrinsic to it (Costère 1954, p. 87), is substituted and expanded by the terms "amphibipolar" — for achiral conformations that have only one pair of poles, one intrinsic and the other extrinsic —, and "amphimultipolar" — for conformations that, having intrinsic and extrinsic poles concomitantly, are either chiral with more than one pole, or achiral with more than one pair of poles. The type *"à pôle cardinal cadentiel"*, used by Costère to name the case in which the conformation has intrinsic weaker secondary poles outmatched by stronger extrinsic main poles (Costère 1954, p. 87), is substituted and expanded by the terms "unisubpolar" or "bisubpolar" — for chiral conformations that only have extrinsic poles but, respectively, have a single weaker intrinsic secondary pole, or are achiral with a single pair of weaker intrinsic secondary poles. The following Fig. 2 illustrates and summarizes these different classificatory types according to the location of the monadic poles:

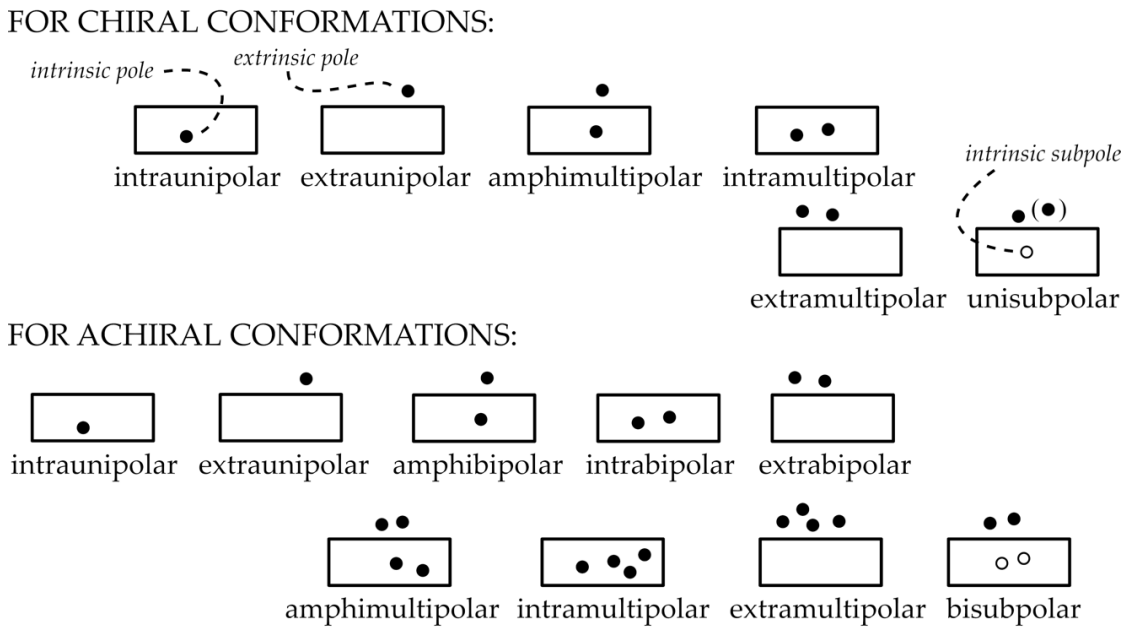

Figure 2: Summary of the conformation types according to the location of the monadic poles

A special type *"à équilibre cardinal"* is also posited by Costère for the case of conformations whose intrinsic metachromas have attractivenesses of equal strength (Costère 1954, p. 87), and in this case the different inspective logic required its substitution by a suitable term with a different derivation, "isotropic", borrowed from the physics field lexicon — which is constructed from the Greek morphemes *"isos"* ("equal") and *"tropē"* ("a turning"), meaning the quality "pertaining to bodies whose properties are the same in all directions" (Thatcher; McQueen 1980, p. 459).

5.6.2. Classification According to the Criterion of Triadic Proclivity

Costère's second proclivity category, "tonal gravitation" (Costère 1954, p. 88), is denominated in the ontology "triadic proclivity", seeking once again the avoidance of a direct connection between tonality and perfect triads. Here, the types posited are based on the investigation of the attractiveness of perfect triads in the context of a conformation and, in this sense, the attractiveness of a triad, either intrinsic or extrinsic, is the sum of the attractivenesses of that triad's individual metachromas. A triad bearing the biggest accrued attractiveness will then configure what in the ontology is called the "triadic center" (or simply "center") of the conformation, a suitable word derived from the Latin *"centrum"* (Onions 1966, p. 158). As such, the triadic stability or instability of a conformation depends on whether its triadic centers are located within itself or not, with the intrinsicality of its centers collaborating for its stability and the extrinsicality of its centers disrupting that stability. If this classification criterion seems to apply naturally to triadic conformations, nonetheless all types according to triadic intrinsicality are evaluable under it: atriadic conformations naturally yield a context in which all triads are extrinsic; for diapentic conformations, the extrinsic triads circumscribed by its intrinsic perfect fifths can be counted as intrinsic.

At this point, the terminology used by Costère for triadic proclivity types also includes some rather intractable terms such as *"gamme détonnante"* and *"gamme cadentielle"* (Costère 1954, p. 89-90) — one being of difficult translation, the other generating inconvenient polysemy with a common music term —, and so it was again substituted in the ontology by suitable neologisms systematically created by adding the already mentioned repertoire of morphemes — *"uni"*, *"bi"*, *"multi"*, *"intra"*, *"extra"*, *"amphi"*, *"sub"* — to the root "center".

Thus, the type *"gamme tonalement stable"*, used by Costère to name the case in which all the conformation's triadic centers are intrinsic to it (Costère 1954, p. 88), is substituted and expanded in the ontology by the terms "intraunicentric" or "intrabicentric" — for conformations that don't have extrinsic centers and, respectively, have only one intrinsic center, or are achiral with only one pair of intrinsic centers, which also serves to name Costère's special subtype *"gamme tonique"* (Costère 1954, p. 91) —, and "intramulticentric" — for conformations that don't have extrinsic centers and are either chiral with more than one intrinsic center or achiral with more than one pair of intrinsic centers. The type *"gamme détonnante"*, used by Costère to name the case in which all the conformation's triadic centers are extrinsic to it (Costère 1954, p. 89), is substituted and expanded by the terms "extraunicentric" or "extrabicentric" — for conformations that don't have intrinsic centers and, respectively, have only one extrinsic center, or are achiral with only one pair of extrinsic centers, which also serves to name Costère's special subtype *"gamme cadentielle"* (Costère 1954, p. 90) —, and "extramulticentric" — for conformations that don't have intrinsic centers and are either chiral with more than one extrinsic center, or achiral with more than one pair of extrinsic centers. The type *"gamme équilibrée"*, used by Costère to name the case in which the conformation's triadic centers are both intrinsic and extrinsic to it (Costère 1954, p. 91), is substituted and expanded by the terms "amphibicentric" — for achiral conformations that have only one pair of centers, one intrinsic and the other extrinsic —, and "amphimulticentric" — for conformations that, having intrinsic and extrinsic centers concomitantly, are either chiral with more than one center, or achiral with more than one pair of centers. The type *"gamme tonique"* by Costère, already mentioned before, also entails a special secondary subtype which in the ontology is renamed "unisubcentric" and "bisubcentric", used for conformations that only have extrinsic centers but, respectively, have a single weaker intrinsic secondary center, or are achiral with a single pair of weaker intrinsic secondary centers. The following Fig. 3 illustrates and summarizes these different classificatory types according to the location of the triadic centers:

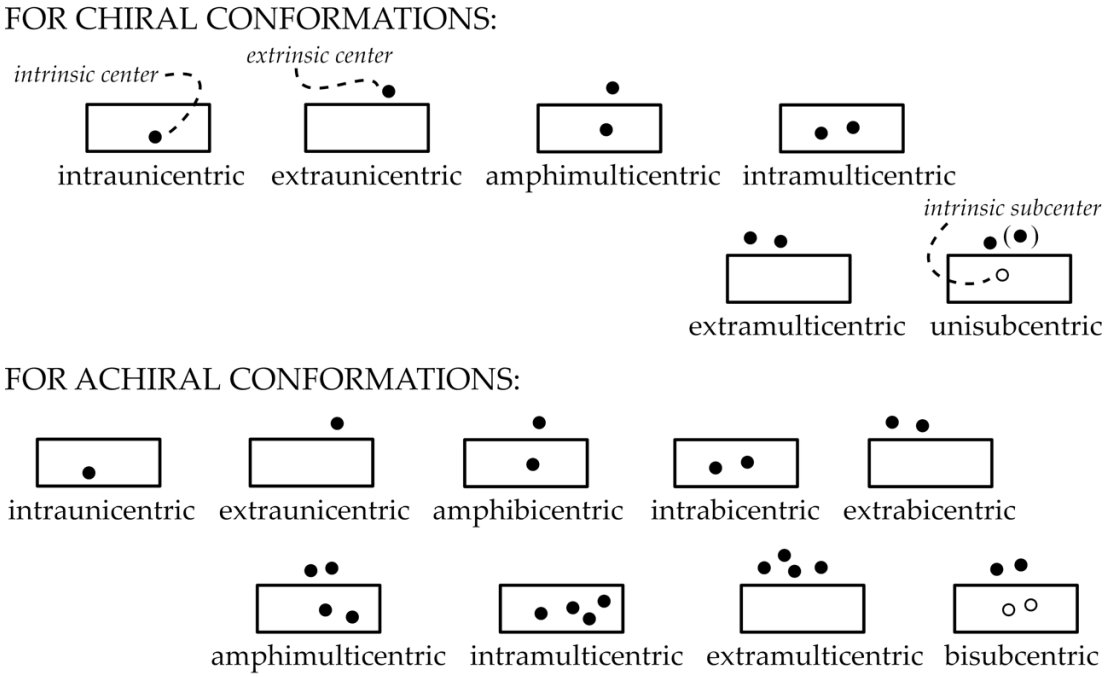

Figure 3: summary of the conformation types according to the location of the triadic centers

5.6.3. Classification According to the Criterion of Transpositional Proclivity

Costère's third and last proclivity category, "transpositional gravitation" (Costère 1954, p. 92), has been kept in the ontology as "transpositional proclivity". Here, the types posited are based on the investigation of how proclive a species of a conformation is to transition towards another species of that same conformation. In this sense, the attractiveness of each species of a conformation is the sum of the attractivenesses of its constituent metachromas, with the evaluation of only the proclivities of the metachromas of one specific species of that conformation. Thus, if the attractiveness of the original conformation species that had its proclivities evaluated is less than the attractivenesses of its other species, then the conformation is considered to be proclive towards transposing itself, and conversely.

Here, the terms used by Costère, *"gamme non transpositrice"* and *"gamme transpositrice"*, already use suitable terms due to their derivation from the Latin *"transponere"* — *"trans"*, "across", with *"ponere"*, "to place" (Davidson 1903, p. 1028) —, and thus could as well have been kept in the ontology unaltered.

Nonetheless, for the sake of parallelism of logic and style with the other terms used, they were also substituted by suitable created neologisms derived by adding to the word "transpositive" the very common Greek morphemes *"anti"* — "against", "in opposition to" (Davidson 1903, p. 37) — and *"pro"* — "in favor of" (Morwood; Taylor 2002, p. 269).

Thus, the type *"gamme non transpositrice"* — used by Costère to name the case in which a species of a conformation is not proclive towards transposing itself (Costère 1954, p. 93) — is substituted in the ontology by the term "antitranspositive". The type *"gamme transpositrice"* — used by Costère to name the case in which a species of a conformation is proclive towards transposing itself (Costère 1954, p. 93) — is substituted in the ontology by the term "protranspositive".

Further expanding Costère's taxonomy, the ontology also posits the types "antireflective" — which is used for a conformation that is not proclive towards reflectively inverting itself —, and the type "proreflective" — which is used for a conformation that is indeed proclive towards such inversion —, both suitable terms using a root derived from the Latin *"reflectere"*, "to bend again" (Onions 1966, p. 750).

5.7. Classifications Regarding Conformation Limitations

Some achiral conformations have a curious property allowing what set-theorists call "complete invariance by transposition" (Forte 1973, p. 37). Treated also by Costère as the type *"gammes à transpositions limitées"* (Costère 1954, p. 70), these are Olivier Messiaen's famous "charm of impossibilities": symmetrical conformations in which some of their transpositions yield species that are completely coincident (Messiaen 1956, p. 58). These "modes of limited transposition", using the same logic of most of the terms in the ontology, are denominated by the suitable created neologism "hypotranspositive", derived by addition of the common Greek morpheme *"hypo"* — meaning "under", "beneath", "below" (Onions 1966, p. 456), used here in the sense of "less than normal". Conversely, this method also allows for the creation of a suitable term for a conformation in which that property of limited transpositions does not occur, that is, for conformations that indeed yield completely unique species for all their transpositions. These are then termed "omnitranspositive", using the

common Latin morpheme *"omni"* — meaning "all" (Onions 1966, p. 627). In the ontology, these types are also expanded beyond Costère's investigation to include the case of complete invariance by inversion (Forte 1973, p. 41), thus creating the types suitably named "omnireflective" and "hyporeflective" for conformations that, respectively, yield or do not yield completely unique species for all their reflective inversions.

The next limitation to be seen is found in the inspection of the intervallic content of a conformation — what set-theorists call the "interval vector" of a set (Forte 1973, p. 13) —, verifying if its inventory includes all the different types of intervals possible or not, a property that Costère also investigates as his types *"gammes à intervalles multiples"* and *"gammes à intervalles limités"* (Costère 1954, p. 69). For substituting these, the ontology continues with the same derivational logic, adding one of the already mentioned morphemes *"omni"* and *"hypo"* from Latin and Greek to the word "interval" — which is naturally not only an unavoidable ubiquitous term from the music field lexicon but also suitable due to its derivation from the Latin *"intervallum"*, meaning literally "space between ramparts", from the conjunction of *"inter"*, "between", with *"vallum"*, "wall" (Onions 1966, p. 482). Thus, the terms formed here are "omni-intervallary" and "hypointervallary", to denote the cases in which the conformation's interval vector includes or does not include all types of intervals, respectively. It is also pertinent to remark here that although "intervallary" is a less known synonym for "intervallic", it has been preferred for allowing direct parallel translations to the Portuguese *"intervalar"* and the French *"intervallaire"*.

5.8. Special Classifications about Superset and Subset Relationships

The first in a series of special classification categories involves the investigation of subset and superset relationships in which a species of a conformation combines with another species of either the same or a different conformation to form a bigger group, evidently a species of a third larger conformation. In this sense, there is a special case of this in which the two conformation species to be combined contain no metachromas in common. This combinatorial relationship is in the music field lexicon usually called "complementarity", a word derived from "complement", that is, "something which completes a whole", and which, aside from being rather unavoidable for

its wide use, is a perfect word to be kept in the ontology, being suitable due to its derivation from the Latin *"complementum"* (Onions 1966, p. 198). Most theorists commonly deal with this type of investigation in the context of complementarity to the whole of the universe of the temperament grid, that is, given a specific conformation species, finding the elements which would complete that species into the dodecachord conformation, which is what set-theorists call finding the complement of a pc-set (Forte 1973, p. 73), also studied by Costère under the name *"gammes complémentaires"* (Costère 1954, p. 66). Unusually, the ontology investigates not only this type of complement but also all other manners in which smaller conformation species with no elements in common can combine to form bigger ones. Thus, in the ontology we speak of complementarity "to a conformation", specifying to which whole that relationship is connected.

There is also a special case of complementarity in which a species of a hexachordal conformation generates its own complement to the dodecachord either by transposition or by reflective inversion of itself, which Costère denominates *"gammes reversibles"* (Costère 1954, p. 68). In the ontology, the name-terming strategy used to denominate this property was to again create a suitable neologism, the term "autocomplementarity", by addition of the common Greek morpheme *"auto"* — meaning "self", "of or by oneself" (Onions 1966, p. 63) —, followed naturally by the qualification "to the dodecachord". The ontology also expands this notion to investigate the autocomplementarity of conformations smaller than hexachords to supersets smaller than the dodecachord, as for example the case of conformation (0167), which has autocomplementarity to the conformation (0134679d), the octatonic scale — this because the combination of species *n*, (0167) with species *n*+3, (0167) produces species *n*, (0134679d).[3]

Another topic for classification is the investigation of the possibilities of hierarchical organization of a conformation towards a specific one of its subsets. To each possibility of such organization the music field lexicon has already given a time-honored denomination, the word "mode", which is then practically mandated to be kept in the ontology for its ubiquity, what is far from an

[3] A charming musical use example of this specific case of autocomplementarity of conformation (0167) to the conformation (0134679d) can be seen in Béla Bartók's composition "From the Island of Bali", piano piece 109 from his 1940 Mikrokosmos (Bartók 1987, p. 28–29).

inconvenience for its suitability — it is derived from the Latin *"modus"*, meaning "manner", "method" (Onions 1966, p. 583). Nonetheless, there seems to be a lack in the music field lexicon of derived words to denote several properties relating to the concept of mode, with this deficiency made worse by the historical widespread abduction of the term "modulation" as a synonym of "transposition", which is an altogether different idea. So, in the impossibility of further derivating words from "mode" without generating conflicting polysemy, the ontology proceeds by recasting that word as "modalization", which keeps its suitability, original sense and derivation, but allows for fresh new derivative words. This being so, if a conformation includes as one of its subsets a specific smaller conformation, then that superset conformation will have the property of being "modalizable" at that subset conformation, meaning that it is possible in the context of that superset conformation to apply a hierarchical organization towards that specific one of its subsets.

Some conformations include as subsets more than one species of the same smaller conformation. In this case, the superset conformation will then have the property of being "multimodalizable" at that subset conformation, which means that the superset conformation allows for different "remodalizations" at that same subset conformation — both suitable created neologisms made by addition of the already seen Latin morpheme *"multi"* and of the Latin morpheme *"re"*, "again" (Onions 1966, p. 742). In his work, Costère specially investigates in a unique way the specific case of multimodalization at the perfect triad as a type he denominates *"gammes modulantes"* (Costère 1954, p. 81), unfortunately incurring in that polysemy problem with the word "modulation" explained earlier. Although Costère argues he is returning the word to its etymological origins, the inconvenience of this term in his terminology is clear, further justifying its substitution.

The most perfect case of multimodalization is observed by Costère to be the one that occurs in conformations that have the same numerical pattern of metachromas interpolated between the individual elements of each of its multiple subset modalization targets. These conformations allow for the direct transference of a melodic pattern organized around one of those target subsets to the other of its species, all within the strict context of the superset conformation species. In the ontology, this type of conformation is suitably denominated "transmodalizable" at a specific subset conformation, making use of the already

mentioned Latin morpheme *"trans"*. As an example of this, Fig. 4 shows the interpolative situation for the modalization at the major perfect triad of conformation species 0, (012569) — which is multimodalizable at 2, (047) and 5, (047), both these major triads with the numerical pattern of 1, 0, and 2 elements of the superset species interpolated between their own respective subset elements —, followed by a melodic pattern constructed within 0, (012569), first modalized at 2, (047) and then transmodalized at 5, (047):

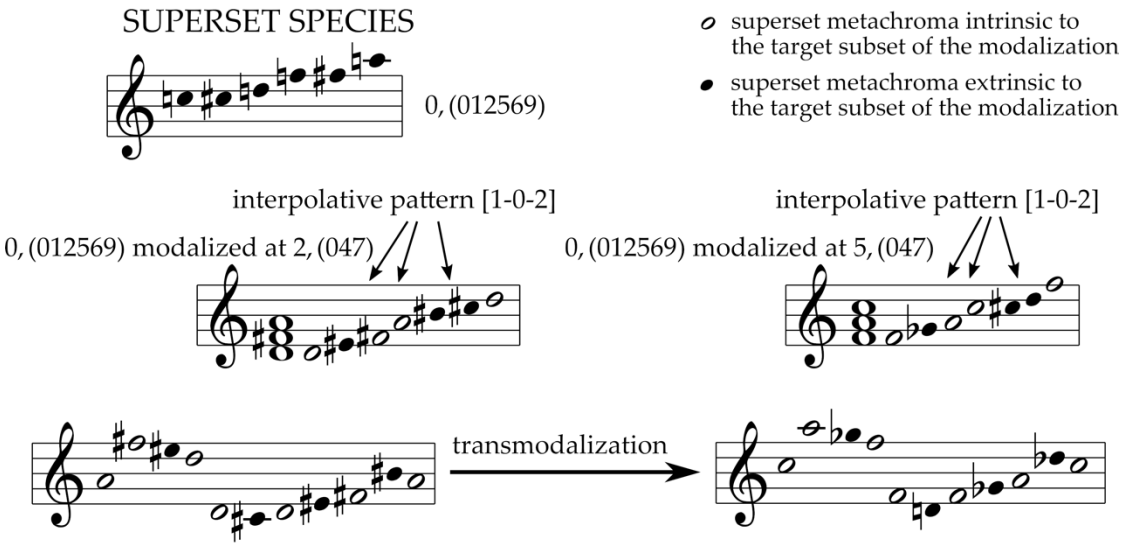

Figure 4: Transmodalization at 5, (047) of a melodic pattern built on 0, (012569) modalized at 2, (047)

Some other interesting combinatorial properties arise from the idea of arranging and numbering the metachromas of a conformation species in sequential order from lowest to highest in pitch, with each of those ordered elements being in the music field lexicon commonly denominated a "step" or "degree" of that species. The operation of substituting a metachroma corresponding to a specific degree number of a conformation species by the element corresponding to the degree a certain number of steps away in that species is in the ontology termed, for the lack of a better or any term, a "transgradation" — yet another neologism derived from the addition of the already mentioned Latin morpheme *"trans"* to the verb "gradate" — meaning "to effect a rising step by step" — derived from the Latin word *"gradus"*, "a step" (Davidson 1903, p. 395), guaranteeing its suitability.

Some modalized conformations that have the same number of metachromas interpolated between the elements of its modalization subset target have the property in which a melodic pattern constructed using elements of the subset target as structural points allows itself to be transgradated into a resulting pattern that will still conserve at its structural points elements of that same subset target. In the ontology, such conformations are then said to have the property of "autoimitability" at that subset conformation species, another suitable neologism made out by addition of the already mentioned Latin morpheme *"auto"* to a derivation of the common word "imitative", meaning "inclined to imitate", derived from the Latin *"imitāri"* (Davidson 1903, p. 456). Costère investigated this property as his type *"gammes à imitations tonales"* — in the specific case of autoimitability at perfect triads —, and the type *"gammes à imitations atonales"* — in all other autoimitability cases — (Costère 1954, p. 82). As an example of this autoimitability feature, Fig. 5 shows the interpolative situation for the modalization at 9, (05) of the same conformation species 0, (012569) seen earlier — which has the same number of 2 elements of the superset species interpolated between each of the target subset elements —, followed by a melodic pattern constructed within 0, (012569) modalized at 9, (05) and then autoimitated by transgradation of +3 degrees:

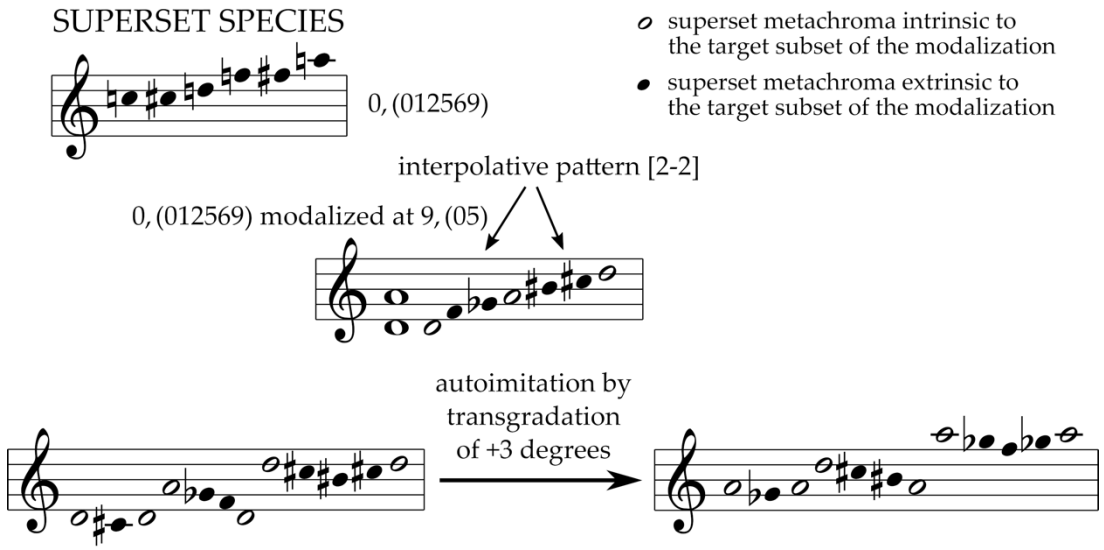

Figure 5: Autoimitation of a melodic pattern built on 0, (012569) modalized at 9, (05)

6. Concluding Remarks

It is most certainly a daunting task to (re)construct an entire ontology, with the process of creating a normalized terminology suitable and appropriate to it being a task just as complex and challenging. What appears at first as a simple task of innocently giving names to things quickly spirals out of control into a labyrinthine, almost interminable circuit of hundreds of terms which must be created with strong logical and historically well-informed and interconnected methodological procedures if the result is to achieve pedagogical gains that are useful. As such, I strived in this text to present the reader with a record and demonstration of the rigor with which this secondary name-terming process was conducted, and it is hoped that it can serve as a quick introduction and summary to the created ontology of music structures that is being developed in the main research work. Although the theory presented here is still expected to undergo further revisions and expansions, it has already been deemed stable enough to be used regularly as a pedagogical device in undergraduate and graduate music courses in composition and analysis, although always with the utmost care to not have the new terminology introduced without the recourse of mediation with the older historical ones. To close this text, the following three figures (Figs. 6, 7, and 8) provide a schematic view of the organizational structure of the ontology, with each figure providing the translation of the terminology to one of the main languages used in the research: English, Portuguese, and French.

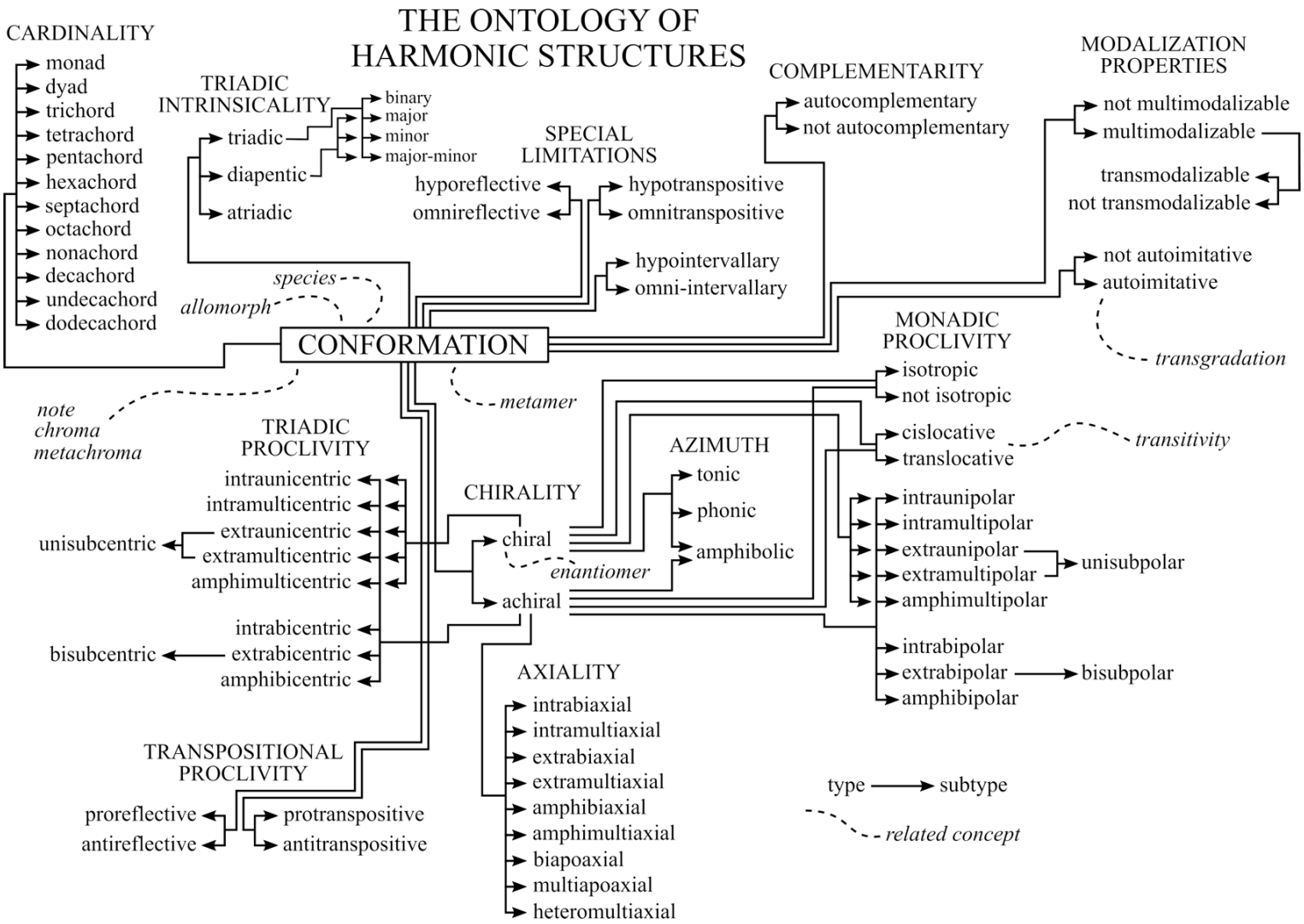

Figure 6: Schematic View of the Ontology of Harmonic Structures (English Version)

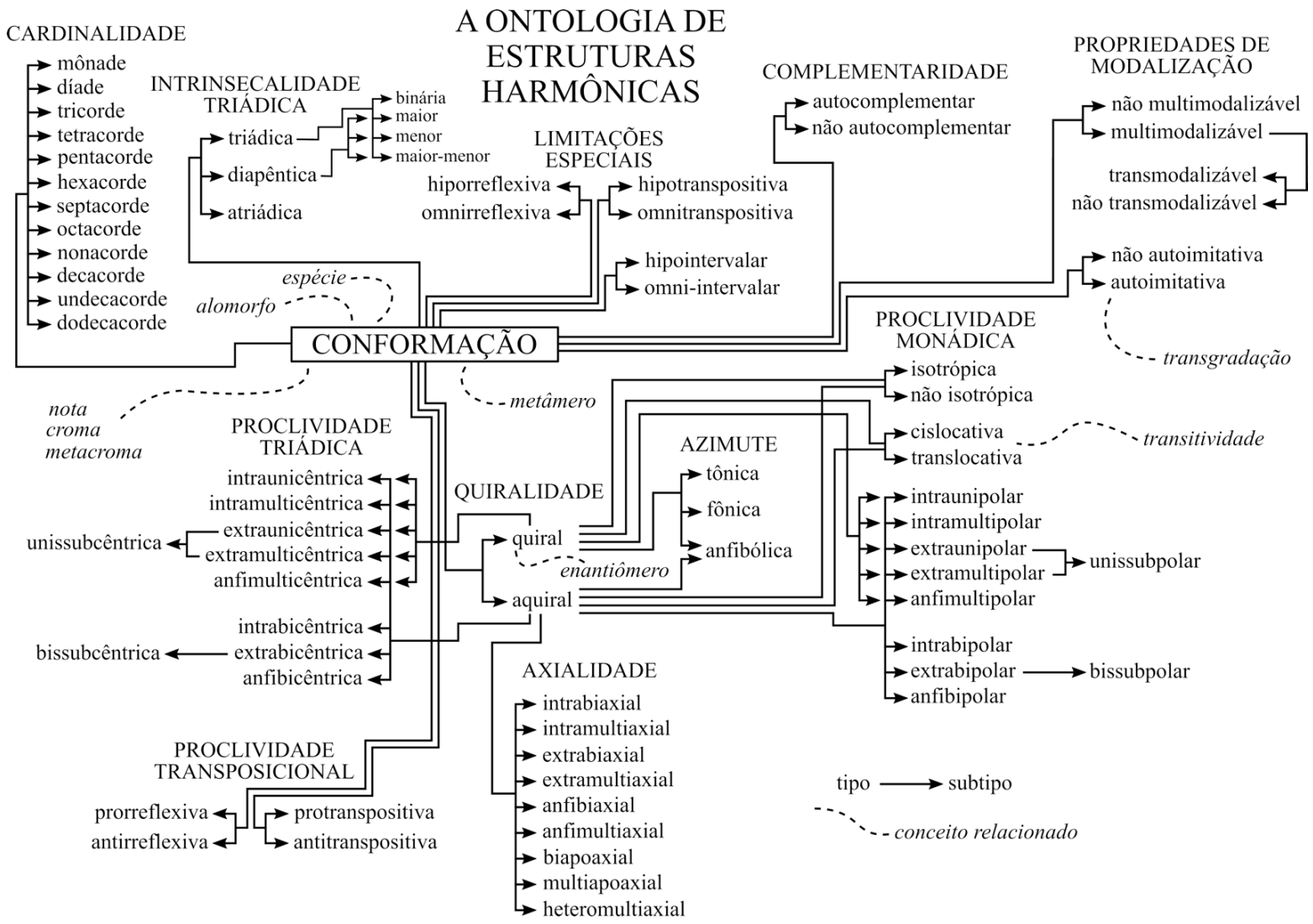

Figure 7: Schematic View of the Ontology of Harmonic Structures (Portuguese Version)

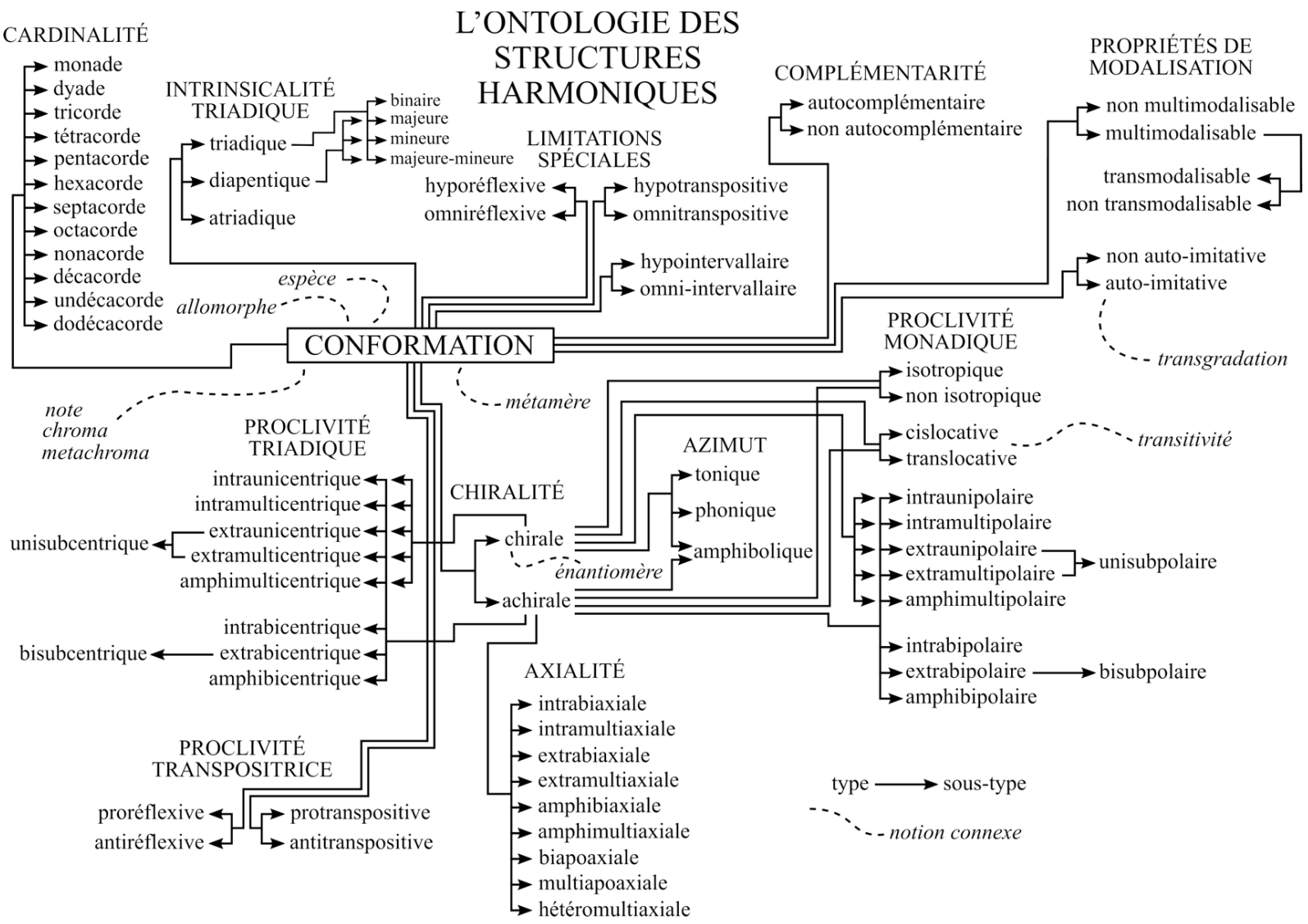

Figure 8: Schematic View of the Ontology of Harmonic Structures (French Version)

References

1. Bachem, Albert. 1937. Various types of absolute pitch. *Journal of the Acoustical Society of America*, Volume 9, Issue 2, p. 146–151.
2. Barbour, James Murray. 1951. *Tuning and Temperament*: A Historical Survey. East Lansing: Michigan State College Press.
3. Bartók, Béla. 1987. *Mikrokosmos for Piano*: New Definitive Edition, volume 4. London: Boosey and Hawkes.
4. Bittencourt, Marcus Alessi. 2016. Rethinking Modal Gender in the Context of the Universe of Tn-Types: Definitions and Mathematical Models for Tonicity and Phonicity. *Revista OPUS*, Associação Nacional de Pesquisa e Pós-Graduação em Música (ANPPOM), Brasil, v. 22, n. 2, p. 399–428.
5. Brenet, Michel. 1926. *Dictionnaire Pratique et Historique de la Musique.* Paris: Librairie Armand Colin.
6. Bynum, W.E; Browne, E.J.; Porter, Roy. 1981. *Dictionary of the History of Science.* London: The Macmillan Press Ltd.
7. Costère, Edmond. 1954. *Lois et Styles des Harmonies Musicales.* Paris: Presses Universitaires de France.
8. Davidson, Thomas (ed.). 1903. *Chamber's Twentieth Century Dictionary of The English Language*. Edinburgh: W. & R. Chambers Ltd.
9. D'Indy, Vincent. 1912. *Cours de Composition Musicale*, premier livre. Paris: A. Durand et Fils.
10. Dubois, Jean; *et al.* 2002. *Dictionnaire de Linguistique*. Paris: Larousse.
11. Ellard, Brian. 1973. *Edmond Costère's Lois et Styles des Harmonies Musicales, an English translation and commentary.* Rochester: University of Rochester PHD thesis, Eastman School of Music.
12. Forte, Allen. 1973. *The Structure of Atonal Music.* New Haven: Yale University Press.
13. Guillaume, Antoine; Koch, Harold. 2021. *Introduction: Associated Motion as a grammatical category in linguistic typology*. In: Guillaume, A.; Koch, H. (Eds.). 2021. Associated Motion, p. 3–30. Berlin, Boston: De Gruyter Mouton.
14. Hanson, Howard. 1960. *Harmonic Materials of Modern Music:* Resources of the Tempered Scale. New York: Appleton-Century-Crofts Inc.
15. Kelvin, William Thomson (Lord). 1894. *The Molecular Tactics of a Crystal.* Oxford: The Clarendon Press.

16. Kroeger, Paul. 2005. *Analyzing Grammar:* an introduction. Cambridge: Cambridge University Press.

17. Leibniz, Gottfried. 1996. *New Essays on Human Understanding.* New York: Cambridge University Press.

18. Messiaen, Olivier. 1956. *The Technique of my Musical Language.* Paris: Alphonse Leduc.

19. Morwood, James; Taylor, John (eds.). 2002. *Pocket Oxford Classical Greek Dictionary*. Oxford: Oxford University Press.

20. Oettingen, Arthur von. 1913. *Das Duale Harmoniesystem.* Leipzig: C.F.W. Siegel.

21. Onions, Charles T. (ed). 1966. *The Oxford Dictionary of English Etymology.* Oxford, England: Clarendon Press.

22. Rahn, John. 1980. *Basic Atonal Theory*. New York: Schirmer Books.

23. Rameau, Jean-Philippe. 1722. *Traité de l'Harmonie Reduite à Ses Principes Naturels.* Paris: Jean-Baptiste-Christophe Ballard.

24. Sager, Juan C. 1990. *A Practical Course in Terminology Processing.* Amsterdam, Philadelphia: John Benjamins Publishing Company.

25. Schaeffer, Pierre. 1966. *Traité des Objets Musicaux*. Paris: Éditions du Seuil.

26. Schuijer, Michiel. 2008. *Analyzing Atonal Music:* Pitch-Class Set Theory and Its Contexts. Rochester: University of Rochester Press.

27. Sowa, John F. 2000. *Knowledge Representation:* Logical, Philosophical, and Computational Foundations. Pacific Grove, California: Brooks Cole Publishing Co.

28. Spinoza, Baruch. 1949 [1677]. *Ethica Ordine Geometrico Demonstrata.* In: Ethics & On the improvement of understanding. New York: Hafner Press.

29. Thatcher, Virginia S.; McQueen, Alexander (eds). 1980. *The New Webster Encyclopedic Dictionary of The English Language*. Chicago: Consolidated Book Publishers.

30. Vaan, Michiel de. 2008. *Etymological Dictionary of Latin and the Other Italic Languages* (Leiden Indo-European Etymological Dictionary Series, 7). Leiden, Boston: Brill.

31. Weisstein, Eric W. 1999. *The CRC Concise Encyclopedia of Mathematics*. New York: CRC Press.

32. Wüster, Eugen. 2003. *Introducción a la teoría general de la terminología y a la lexicografía terminológica.* Barcelona: Institut Universitari de Lingüística Aplicada/Universitat Pompeu Fabra.