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Portfolio of Compositions and Critical Writing

Critical Writing

(An Exploration of the Connections between Music Theory and Cognition in Composition)

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Abstract of Critical Writing

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This study is an exploration of the integration in composition of theoretical and psychoacoustic properties of pitch and duration; its aims are essentially practical in showing how cognitive research can inform composition, but it also addresses more broadly the value and role cognition can have in the current musical compositional climate.

Various contexts for this exploration are discussed: the mediating role analysis has within theory and composition; constraints imposed by aesthetic positions and music theory/pedagogy templates; the role of cognitive psychology in connecting music templates and listening experiences; and the ultimately mythopoetic rather than scientific nature of any such theory/psychology integration.

Using Huovinen's "pitch constellation" approach and Lerdahl's theory of tonal pitch space, a hierarchical pitch-space is set up for the string piece *ed erra l'armonia*, developing from pc set 5-22 a non-standard octatonic scale (pc set 8-27) as the basic pitch collection of the piece. Similarly, using the works of Fraisse, Hasty and London, a hierarchical rhythm-space is set up for the orchestral piece *Pneuma* developing, from the indifference interval in duration, the temporal and metric envelops and the duple and triple subdivisions of the tactus, a three layered metrical structure as the generative rhythmic template of the piece. This is contextualised against the problematic notion of metre in modern art-music. General characteristic of both spaces are discussed: redundancy according to information theory, hierarchy in relation to cognitive opaqueness, salience and association; and elaborational and permutational processes.

It is argued that composition needs to bridge, in practice, the gap between music theory and psychology of music, looking beyond their often absolutist positions; that cognitive constrains in music should be seen as opportunities to work compositionally along the mind's cognitive grains in order to maximise structural and expressive communication; and that at a time of a 'deregulated' musical language it is necessary to re-develop cognitive heuristics to secure the connection between compositional choices and listening experiences. Three principles are given as guidelines for the alignment of theoretical and cognitive issues in composition. It is proposed that cognitive analysis should be developed as an independent discipline as well as a compositional tool, and that the connections style/cognition should be looked at more closely to gain a more unified perspective on diverse (and divisive) stylistic musical camps.
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An Exploration of the Connections between Music Theory and Cognition in Composition

Alessandro Timossi

1) Preface: discovery of 5-22

A list of pc sets in prime form and of their interval vectors (iv) might seem somewhat removed from practical compositional concerns; however, by studying musical material presented in this simple yet comprehensive manner, intriguing discoveries can be made and pursued in composition.

The most widely used list of pc sets is Forte's (1973: 179-181). In order to make a systematic investigation of how these pc sets sound, which is a primary concern for their use, one has to be aware that prime forms sometimes hide important musical features that cannot immediately be unveiled by compositional processes that do not rely on formalised algorithms, such as those proposed by Morris (1987).

A classic example is pc set 3-11 (0,3,7), which is the prime form of both the major and minor triads; if inverted mirroring of intervals hinged on pc0 is not considered, immediate evidence of the major triad would be difficult to find. It is perhaps a curious coincidence that the foundation-chord of tonal music, and much modal polyphony too, does not appear explicitly legitimised in arguably the major seminal book on the structure of atonal music. In any case, this applies to other pc sets too. For instance, Carter's own pc set list includes aggregates that, though possessing the same iv content, have prime forms different from the accepted theoretical standard of Forte and others (e.g. Rahn 1980; Straus, 1990). According to Schiff, Carter's method of listing chords is "intuitive and pragmatic, related to compositional needs at hand" (Schiff, 1998: 324). This has also been my own experience during my empirical, compositional exploration of all possible five-note sets.

Of these sets, one in particular has caught my interest: pc set 5-22 (0,1,4,7,8) [202321] (Fig.1). This five-note aggregate has the property of including all four types of third-based triads (major, minor, diminished and augmented), each just once and without any residual element. It is maximally efficient in its constitution, complete and economical in its content, and unique in status among pc sets of all cardinalities; it is a fascinating musical object whose vertical and horizontal use can extend the practical and aesthetic scope of triadic harmony at a different level of integration and coordination of multiplicity; it is a set with a rich, multifaceted internal structure, one that can generate and sustain an articulate music discourse.

Fig.1, pc set 5-22.

In analytical literature based on pc-set-theory, 5-22 tends to appear only tangentially. The few examples in Forte do not give any evaluation of it, and he only specifically mentions Perle's definition of it as "a diminished triad with a conjunct semitone not only superimposed…but also subimposed" (Forte, 1973: 12, note). Studies on some of the great modernists, such as Bartók (Lendvai, 1971; Antokoletz, 1984 and Wilson, 1992) and Webern (Forte, 1998) seem to be mainly concerned with symmetrical musical systems, for example the symmetrical octatonic scale, to pay too much attention to this pc set that, although in itself symmetrical, is not included in that particular scale. In fact, van den Toorn considers the occurrence of 5-22 in the "Sacrificial Dance" of Stravinsky's *The Rite of Spring* explicitly as a set that misses "the octatonic order by a single step" (van den Toorn, 1987: 209-201). Forte, while detecting it in several passages of the same piece, does not include it in the list of "main harmonies" (Forte, 1978: 132). A more significant mention of it is made by Perle in his analysis of Scene I, Act II of Berg's *Wozzeck*, where he considers it "the principal aggregate formation" in the recapitulation of the music material (Perle, 1981: 36).

More practically oriented works on musical composition, such as Hindemith's (1942) and Messiaen's (1944) do not mention it, either melodically or harmonically. It is included, however, in a couple of examples of polychords in Persichetti's survey of twentieth-century harmony, where a distinction is made between the overall effect of the chord when placing the major or the minor triad in the lower half, one being judged as "acid", the other as "more resonant" (Persichetti, 1961: 142-143).

5-22 has in fact a striking sound quality, exemplified by two practical instances of its vertical use. It can be found in De Falla's *Fantasia Baetica* (1919), in what seems to be a simultaneous statement of a chord (E major) and its *appoggiature* (C natural and F natural). It is a highly dynamic element in a *Giocoso (molto ritmico)* passage that imitates the *rasqueado*, a typical Spanish guitar playing technique, and which adds a rather rough colour to a strongly cadential passage (Fig.2).

Fig.2, De Falla, *Fantasia Baetica*, bars 9-10; 5-22 is the chord C, F, G#, B, E; Chester Music.

It can be also found in Puccini's *Turandot* (1926), particularly in the *enigmi* related scenes. It is used to underpin, in short intense sound-bursts, the public announcements of the *enigmi* challenge, presented unequivocally (in its notation) as the superimposition of a major triad above a minor one (Fig.3). This use brings to the fore its enigmatic, contradictory nature and when, at the beginning of the opera, the Mandarin announces to the crowd assembled that the Prince of Persia is to be executed, its colour becomes particularly "acid" and twisted.

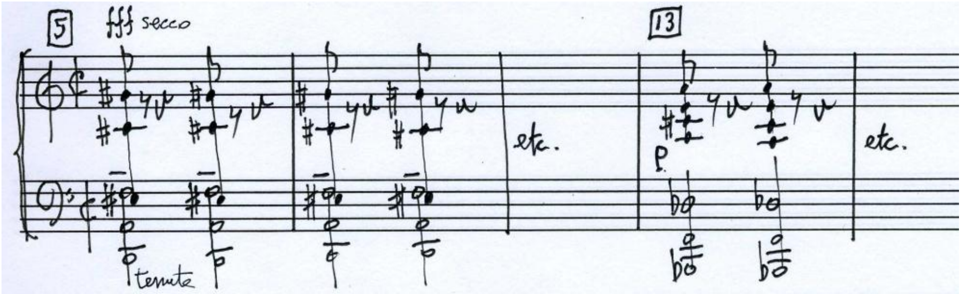

Fig.3, Puccini, *Turandot*, bars 5-6 and 13; 5-22 is D, A, F/E#, C#, G# and Bb, F, Db, A, C#, E.

The role of 5-22 in these two cases is determined by the set's harmonic colour more than its potential structural functions and therefore, while expressively perfectly integrated in the music, in terms of harmonic language its use is rather more accidental. The compositional issue arises, then, as to whether it is possible to focus on the set's structural characteristics in order to explore both its musical resources and its cognitive valence for a functional use in composition.

2) Introduction: contexts of the exploration

2.1) Analysis and theory in composition

When a composer engages with theory in order to develop ideas, materials and strategies for new pieces, a fundamental issue arises: from general abstractions he or she needs to create concrete individual outcomes. This poietic journey that connects the abstract and the concrete evolves along an imaginary path where analysis plays a prominent, Janus-like role. If we travel from composition to theory, analysis has the task of abstracting from the particular the general upon which the theory relies; if we travel in the opposite direction, analysis has to find ways of instantiating general ideas so that they can become concrete musical works. Rahn evaluates initial abstraction processes in the consideration of pitch intervals saying that "by *giving up* information about the details…we have *gained* information about structure" (Rahn, 1980: 29-30); a composer's task includes also the opposite, which is to work through abstract structures to gain tangible details. This practice is cyclical; as soon as a detail is reached, composers need to abstract its generalities for it to be fed back into the compositional process.

2.2) Multiplicity and coherence

Recent music theories and analytical models are of interest for their application to the compositional process, for detecting and releasing the possibilities of musical material and for seeking, through the connectedness of these possibilities, a source of artistic legitimisation. In this process they, even if *prima facie* heterogeneous, can work alongside one another and unlock musical perspectives that remain otherwise difficult to identify and to connect, or contradictory on the surface.

These theories and analytical models often develop in connection with certain specific compositional styles and associated repertoires, for example GTTM and tonal pitch-space for tonal music (respectively Lerdahl and Jackendoff, 1983; and Lerdahl, 2001), PC set theory for atonal music (Forte, 1973; Rahn, 1980; Straus, 1990 and others) and neo-Riemannian theory mostly for nineteenth century harmonic language (e.g. Cohn, 1997, 1998a, 1998b, 2000). There is however no reason why, if their processes are reversed and applied to writing music rather than to analysing it, their specificity should be a hindrance to compositional concerns that are not necessarily connected with these original stylistic environments.

A reversed use of these different approaches is therefore conceivable in composition, one that can also combine them in a way that is synergetic rather than exclusive, and practical rather than ideological. Even musical outcomes commonly perceived as being stylistically in opposition or mutually incompatible can be artistically supported and justified as belonging to different portions, or to different projections, of the same basic interconnected musical material following different explorative procedures. This heterogeneity can legitimately be part of a composer's artistic scope in general, and also of individual compositions. Cross says that "the oppositions of a modern work of art can be understood to take place within a context which gives those oppositions meaning but never negates their strength as oppositions" (Cross, 1994: 189). The context that justifies outcomes in apparent contradiction can very well be the network of the musical material's relations that emerges through different analytical explorations.

Compositionally speaking this means that the legitimation and coherence of musical outcomes can be considered in relation to the number of musical possibilities that emerge through the application of different theoretical and analytical models. As these possibilities are unpacked, the composer needs a sensitive navigation system in order to proceed. Hindemith states that "the very quantity of the [musical] material commands the composer's thorough consideration, and 'inspiration' and 'invention' can be effective only on the basis of adequate technical knowledge" (Hindemith, 1942: 87). If technical knowledge is at the basis of meaningful artistic progress, it is itself, and in its deeper sense, ultimately generated by the composer's artistic conception and desire for exploration and communication, by his/her resourcefulness and stamina in travelling through various musical landscapes. Conception and technical knowledge are inseparable parts of the creative process, a process that goes beyond its instantiation in finite pieces of music. Their reciprocal dynamic relationship is a game in which they are in a constant, ambivalent state of dependence and independence, supremacy and support, and that keeps the composer's mind tied to a continuous musical journey that renovates itself at every turn.

2.3) Constraints and freedom

As well as creating possibilities, applying theoretical and analytical models to composition generates a significant number of constraints. Questions arise, then, as to the nature of these constraints, their usefulness if any, and whether musical material developed in this way would itself be subjected to deterministic outcomes: what of artistic freedom in this context? Freedom here is intended in a generic sense, without considering the effects on composers of external factors or of internal prejudices, be they conscious or not. Whether real or imagined, freedom remains a fundamental tenet in artistic matters.

Composers have been keen to look at these restrictions in a positive frame-of-mind. Stravinsky wrote:

> My freedom…consists in my moving about within the narrow frame that I have assigned myself for each one of my undertakings...my freedom will be so much the greater and more meaningful the more narrowly I limit my field of action. (Stravinsky, 1942: 65)

Here freedom is placed in direct, almost necessary, relationship with constraints. At the centre of a poietic principle and of an ethical position on artistic integrity, it is portrayed as an active protagonist that is born out of, and feeds on, limitations, and that challenges and defies them. In fact, each step towards "narrowly limiting the field" and assigning to oneself a "narrow frame" is itself an act of free individual choice, guided and produced by the artist while mediating between the creative vision and the created outcome. Each step towards generating and selecting the musical material of a piece is therefore also the outcome of a cumulative, and narrowing, set of free choices leading towards the artistic goal; constraints make the imagination resourceful, and alert; they can be, ultimately, opportunities. A restricted musical landscape gives a set of extensional loci and relational laws that enable the movement itself.

Another way of looking at these constraints considers not their invigorating effects on the act of composing, but the intrinsic quality of material obtained. Messiaen writes about what he defines as the "charm of impossibilities" of modes of limited transpositions and of non-retrogradable rhythms: "this charm, at once voluptuous and contemplative, resides particularly in certain mathematical impossibilities of the modal and rhythmic domains" (Messiaen, 1944: 8). This approach not only immediately positions the qualities of constrained material on an aesthetic, expressive level but, as "mathematical impossibilities", makes them acquire a deeper ontological status. Going beyond the simple process of "narrowing the field", they attain an almost universal, quasi-cosmological status, and Messiaen finds traces of them in ancient, traditional material (i.e. Hindu rhythms), implicitly thus enhancing their claim to universality and spirituality. Even without conceiving constraints (or impossibilities) in these terms, an aesthetic approach to them may still be adopted; after all, music theory and analysis are also grounded in the specificity of real, existing music and they also operate and often self-impose a similarly constrained set of conceptual and practical parameters. They also are subject to the "charm" of ontological or spiritual constraints.

Stravinsky describes how he recovers from "the anguish" of "unrestricted freedom" – "I have no time for theoretical freedom" - by always being able to turn to "concrete things that are in questions" (Stravinsky, 1942: 64). Using theoretical and analytical models in composition can be just this: a way of finding solutions to practical compositional problems. This position finds a similar advocate in Hindemith, particularly in relation to processes of composition relying on mathematical means. He writes that:

> For the musician who, despite the intangibility of his building material, is a healthy realist in his craft, numbers and intervals are of value only as sounding entities. He will accept calculations employing proportions and curves only if they seem to offer practical advantages in the solution of musical problems. (Hindemith, 1942: 64-65)

Thus pragmatism seems to be a healthy and liberating attitude for both, for one an antidote against "theoretical freedom", for the other a strategy to keep a balance check against self-serving reliance on numbers and calculations despite the "intangibility" of musical building material. Similarly, on applying theoretical and analytical strategies to composition, Cook suggests that:

> such an approach…is perfectly valid as regarded as a compositional heuristic…a mechanism for creating new and possibly interesting sound-combinations to be validated empirically through listening. (Cook, 1990: 231)

2.4) Music foundational templates

It would be only part of the picture, however, to concentrate on the empowering, allegedly freedom-enhancing constraints consciously chosen and applied during the composition process and that might come from specific theoretical and analytical models, often worked out in practice through sketches on paper and in the mind.

Composing is deeply grounded in fixed musical templates that pre-shape and ring-fence our ways of relating to music into usable chunks and understandable relations; for instance, but not only, fixed structures in which physical conditions of continuous frequencies and continuous durations are organised on a human scale of pitch and rhythm for human consumption. Composing is conditioned by, and an enactment of, the ways in which these templates themselves function, and by the practices of working through, and sometimes against, these pre-shaped musical elements and habits. Hidden somewhere in both the abstracting and the instantiating processes of composition, and leading them both along, lies some kind of template of musical materials and of methods to operate with them.

Templates are intended here as formalised inventories or spatialised visualisations of musical materials and processes across most musical parameters. They are the product of the kind of music descriptions and explanations that incorporate everything from intervals and scales, from rhythm and metre, to notation, to standard concepts and terminologies and to formal descriptions of pieces and genres. Most of them are poietic heuristics, experience-based ways of doing music that have been systematized and codified primarily with a practical and pedagogical aim in mind; these are broadly referred to, here, as theory/pedagogy templates. Examples of these include time signatures, modes and scales, the circle of fifths and others. Other templates are *ad hoc* creations to explain certain pieces or certain styles, and are broadly referred to, here, as theory/analysis templates. The examples used earlier of GTTM, tonal pitch-space, pc-set and neo-Riemannian theories are examples of the second type, and come invariably equipped with sophisticated visual apparati (often called ‘spaces’, for instance a pitch-space, a rhythm-space).

My starting point is the set of learnt foundational templates of theory/pedagogy that are at the basis of Western music. It is fair to think that these emerged by trying out and filtering through experiences in composition, performance, listening, theorising and pedagogy and whose primary but not exclusive aim is, as mentioned above, organising musical material for practical use and general understanding. This organisation operates often according to a specific set of relationships among its members (e.g. a C major scale; beat hierarchies in a 4/4 bar) or absolute values (e.g. the octave divided into 12 equal-tempered semitones; the standard binary subdivision of musical durations), or taxonomies of behaviour of musical material (e.g. types of cadence, structure of musical phrases, lists of possible dynamic marks, organisation of timbres).

Practical and theoretical music experiences necessarily interact with these templates and can lead to their fine-tuning or to radical shifts in them or, as it is more often the case, to the continual adoption of particular ones with different stylistic contexts and outcomes. In these cases, the ways they are used are not only highly individual, but also directed by common tastes, by style/genre contexts, and by more general external factors.

These templates, therefore, are not static. In some cases they evolve over generations and artistic epochs. *Common practice*, for instance, refers to shared templates in tonal music that are the process of a slow consensual development and whose pervasive influence is subtle and extensive in very many aspects of music today, and may remain undetected not only to those who use them for practical outcomes (e.g. composers, performers), but also to those who subsequently evaluate these same outcomes allegedly in more absolute terms (e.g. analysts). An extreme, perhaps provocative example of this is the piano keyboard, a very powerful tactile pitch template visually and proprioceptively still central to many practical and theoretical musical experiences. Another example, more recent but based essentially on the same structures, is notational software that, starting from common theory/pedagogy templates and somewhat confounding the composition of music with the notation of it, tries to reduce to templates also the more mercurial and potentially transitory aspects of recent music making (e.g. various modernist idiosyncrasies in the use and notation of pitch and rhythm).

In other cases, particularly but not exclusively since the twentieth century (for a counter example see Vicentino's microtonal *archicembalo* in XVI Italy; Vicentino, 1996/1555: 315, that however was itself trying to recapture different and more ancient tuning templates), this process is a more individual and localised one, often questioning one or another aspect of the given traditional templates, and often simply introducing new ones in their place. Examples include, in pitch, equal-temperament and micro- or alternative tunings (e.g. Haba's quarter- and six-tone temperament, see New Grove II, s.v. 'Haba, Alois'; and Parch's just intonation, see Gilmore, 1998: 48), metrical organisation of rhythm and various alternatives to it (e.g. Messiaen's ametrical music, Messiaen, 1944: 9; Stockhausen's frequency/duration continuum, in London, 2002: 717), and threshold boundaries of sound and noise and of instrumental/vocal techniques (e.g. Schönberg's use of *Sprechstimme* and Lachenmann's *music concrète instrumentale*, see New Grove II, s.v. 'Lachenmann, Helmut').

2.5) Templates' characteristics

There are many templates that apply to a piece at any one time. Remaining within the scope of the very basic traditional ones mentioned above, all play a part simultaneously: those of octave division and tuning, of organisation of durations, of sound colours and of taxonomy of behaviour of musical material. There are three characteristics that are worth mentioning in general.

a) Layering - Templates are layered structures that can operate at different levels at once. There is for instance a level just above the prime layer mentioned in 2.4 that in many ways is even more influential for the ineluctable emergence of stylistic and individual differences, and thus the understanding of individual pieces. This is to do with, to keep to the same categories of examples, how to organise pitch beyond standardised successions of tones and semitones, how to organise durations beyond the normal periodical repetitions of metre, and how to navigate the overlap between what we could define as musical sounds and noises.

An interesting process in pitch organisation, achieved over a long period of time, has been the advance of the 12-note equal tempered scale through practical and theoretical developments in the use and understanding of modes and diatonic scales (see Rash, 2002: 204-210), and in overcoming particular performance issues. Once established, the 12-note scale becomes itself the lower prime layer of a pitch template from where a more selective pitch organisation can be devised (e.g. the whole-tone and octatonic scales, but also quarter-tone micro-tuning; all literally inconceivable if not within the lower prime layer of pitch-organisation from which they stem). The same could be said about rhythms; early development brought the codification of duple subdivision of durations and periodical organisation of metre (see Busse Berger, 2002: 653). These then become the lower prime layer of a template upon which irregular tuplets and ametrical music are conceived. Lachenmann's string quartet *Gran Torso* (1971) is conceived upon the well-established sound-template of the string quartet, upon and against which it builds its own sound-world.

A recent proliferation of theory/analysis templates, devised in order to explain different styles or even individual pieces, mostly takes for granted the foundational theory/pedagogy templates to concentrate on higher layers of structures and behaviour. The examples of Lerdahl and Jackendoff (e.g. their branch-like prolongational reductions of tonal music), of neo-Riemannian (e.g. the various visual ways of connecting triads: *Tonnetz* and *power-towers*), Forte's number-heavy segmentations of musical surfaces, as well as Schenker's *Urlinie* for tonal masterpieces, are all examples of this.

<u>b) Mix of experiential fields</u> - Another important feature of these templates, and of the practices related to them is the loose, instinctive way they themselves come together, combining and codifying practical and cultural musical habits from disparate experiential categories. As an example, it is worth considering the template of tonal cadential behaviour and the terminology used to categorise it, where the traces of this unsystematic development but systematic assimilation are preserved. A cadence can be *perfect* or *imperfect* (aesthetic/logic categories); *deceptive* (psychological category: the listening experience); *interrupted* (in practice the same as 'deceptive', but defined in terms of musical syntax); *plagal* or *phrygian* (the origins of both going back to medieval practices and theory; the latter referring ultimately all the way back to a geographical area in Anatolia and therefore, in some long-ago forgotten way, to a people, a cultural habit). The word *cadence* itself nearly slips away from these considerations undetected, but has its origins in the gravitational experience of 'falling'; some call it 'closure', a physical intentional act rather than one based on the inescapable nature of the physical world (and, in parallel, of musical phrases).

These brief examples point towards the fundamentally open way in which the various fields of musical experience, from aesthetic, to emotional, to structural, to ‘ethnic’, have been put side by side by theory/pedagogy following the development of music practices. The templates of tonal music, but also of much foundational music theory/pedagogy studied today and of well-established practical music habits, present this mostly unproblematic relationship, the result of cumulative poietic procedures and of the porous boundaries between different experiential fields.

c) Numerical processes, geometrical representations – Yet another important aspect of templates is that they often are codified with, and rely upon, mathematical means of organisation. The Cartesian-type space in music notation is such a means, where position in space refers to both pitch (*y* axis) and duration (*x* axis). The circle of fifths is another, where the transposition patterns of scales across the 12 equal semitones is represented neatly as a fully closed, regular circumference; the *Golden Section* and the *Fibonacci Sequence* are two mathematical patterns more recently connected to music (see Howatt, 1983 for Debussy; and Lendvai, 1971, and 1993 for Bartók). In these as well as in other cases, the positioning in space describes, demonstrates and justifies the musical material’s properties and the nature of their inter-relationships. In all these cases, the templates’ synchronic visual impact is itself a powerful practical and pedagogical tool, and its geometrical representation and numerical treatment a source of theoretical speculation and legitimation, and a powerful compositional resource.

Numbers in this context are practical tools to help practical tasks, but they also have an extra, double hold on the human mind: as symbols of some universal value, thus ultimately appealing to human subjectivity; and as logical operators, thus invested of enduring objectivity beyond transitory trends and individual tastes (see also Nolan, 2002: 298).

If numbers provide these templates with the means of rationalisation, self-justification and combinatorial development, the question of if and how these means reflect the physical realities of sound or the psychological experience of music itself remains open. As is well known, the circle of fifth is more like a spiral, it does not close itself neatly back to the starting point; the 12 equal-semitone chromatic scale is an approximation to help practice, and not very well suited even across all current acoustic music scenarios. As soon as the slightest rubato is applied in performance, the *Golden Section* becomes irrelevant in listening as a structuring element of form, regardless of how the music is written, and regardless of whether it would be indeed audible or not.

On the one hand, therefore, numbers are simply coding means of human approximations of the physical phenomenon of sounds and durations for human consumption, means to manipulate an engineered version of reality. They help to formalise and make functional these wonderfully approximate, and recently deeply individual, musical systems (see for instance Cross, 2003).

On the other hand, as soon as the reality/artificiality boundary is crossed and numerical encoding has happened, the persuasive power of numbers takes over on the strength of its intrinsic logic and abstract combinatorial powers and, for some, of the aesthetic value of such combinations. Numbers are then seen as guarantor of some universal musical truth, of abstracted structures and conceptualised beauties. They, and the music based on them, acquire both a symbolic (for instance in Bach and Messiaen) and a philosophical value (see Wolff and Leibnitz, in Butt, 1997: 60) beyond the immediacy of sound. A description of musical structures through numbers becomes possible, which mimics the scientific method in its objectives and conclusions, and can (or need, see for instance Babbitt, in Guck, 1994) be conveyed by a use of language that follows standards of scientific explanation.

This is a further example of the porous boundaries between different experiential fields in music, in this case those attached to mathematical means. These fields are the physical nature of sound, its numerical approximate codification for practical and pedagogical use, and the potential for these numbers to take over as independent self-justifying agents that give back a semblance of universality and necessity to music material and music processes that are often much more spontaneous operation within the foundational templates mentioned earlier.

2.6) Templates and music cognition

Of interest for this study is how much either the theory/pedagogy templates or those of theory/analysis relate to listening experience. I have referred to the spontaneous and open process of crossing experiential boundaries in the creation of these templates, particularly the foundational ones, and to their mathematical formalisation that becomes in itself a means of their own self-justification and development. In both, cognition plays a fundamental role, in the first case as a bottom-up process of organisation of raw experiences (e.g. listening), in the second as a top-down process of codifying these experiences into mental and cultural schemata (see Clarke, 2005: 11-16, for a representation and critique of this model of cognition). However, this is not enough, because these two cognitive processes do not need to be entirely compatible; it is possible for the top-down process to override and mislead the bottom-up one into illusionary conclusions; it is possible for the bottom-up process to seduce the other beyond familiar schemata, while not altogether confounding it. Basically, it is possible for the formalised templates to trick listening into pre-set categories, and for the psychoacoustic experience to expose limits and contradictions in the templates themselves.

Music psychology has built an impressive set of its own templates to address this issue. It operates essentially on the foundational templates as well as on those developed *ad hoc* by composers and musicologists, and has been particularly active in the areas of rhythm, pitch and tonality, voice leading and melodic progressions. It searches empirically for a means of understanding the psychoacoustic experience of music and often visually summarises its findings using itself also a Cartesian space that can be often conveniently mapped onto both the theory/pedagogical and the theory/analytical templates. It is an experimental science grounded in evidence from the physical and mental worlds, and therefore its use of a scientific language is somehow more substantiated than the self-referential codification of theory and analysis. For this reason it has come frequently into conflict with them because, as Ockelford puts it, the "proponents of the two camps feel that they have an equal claim over a common territory" (Ockelford, 2009: 542); they both declare to have the means to probe deeper than the other into the essence of music. Clarke investigates these differences and points towards the need of a combined route forward; musicology formulates “theories of the structural relations within and between musical works” and psychology develops “theories of the mental processing of musical events”, but the two are in fact “complementary”, with “potential for considerable mutual benefit” (Clarke, 1989: 2).

Attempts at some kind of synergy have been made, for example by Meyer (1956, 1973), Cooper and Meyer (1960) and Lerdahl and Jackendoff (1983). Among these, two studies in particular have been influential for me, and I will discuss them in turns in the following pages: Lerdahl’s tonal pitch-space (Lerdahl, 2001) and London’s notion of temporal envelope (London, 2004). They both link foundational theory/pedagogy music templates with templates of music cognition, and offer yet a different approach to the issue of how to understand pitch and rhythm in music, both in tonality and in post-tonality. They both can also be reversed from means of understanding into means of doing and, therefore, can be used for compositional purposes. In this respect, they can be added to other traditional tools of composition for creating, analysing and developing musical material, and can bring some form of reality-check on what constraints (and opportunities) are inescapable if music needs to remain within a certain cognitive reach.

One central area of interest for music psychology is that of the hierarchical nature of cognition. In general this relates to models of human memory, intelligence and learning (see Gross, 2005: 297, 707 and 183) and visual processing (see Eysenk and Keane, 2005: 41-43), and consists first of all in singling out individual processes and then in linking them together as different stages of a unified pyramidal cognitive structure that starts from a broad base at the bottom (sensations) and selectively climbs up towards a narrow point at the top (understanding). It moves roughly from plurality to selection and synthesis, from raw reality to structured knowledge. Though not the only psychological process in the experience of music, it is nonetheless important because it somehow mirrors music templates both in composition and in analysis, particularly those that are concerned with patterns of structural organisation, of stability conditions and of the centrality of referential pitch and metre. Thus we have the overlapping of compositional processes based on formal properties of the material and on the establishment of priorities of various kinds, and of mental processes that, regardless of what they apply to, spontaneously select and order sensations according to what is perceived to be more or less important, and to what has synthesis/organising cognitive power.

In Lerdahl's words, musical hierarchy is "an organisation of discrete elements such as one element is perceived to subsume or contain other elements" (Lerdahl, 2001: 5). It is considered to be a "critical feature" of Western tonal music (Bigand and Poulin-Charronnat, 2009: 59) and, because it has been detected in other musical cultures too, it has gained the reputation of a "possible universal" process in music cognition (Stevens and Byron, 2009: 16). Following Bharucha (1984), a distinction is made between tonal and event hierarchies in music, whereby the first designates an atemporal schema of pitch and rhythm regularities (see Bigand and Poulin-Charronnat, 2009: 60), and the second represents "hierarchical relationships inferred from a sequence of events" (Lerdahl, 2001: 41). As Lerdahl states, the two are interconnected:

> tonal and event hierarchies are interdependent developmentally. Exposure to music is a prerequisite for internalising a tonal hierarchy, yet a complex event hierarchy cannot be construed without such a schema. (Lerdahl, 2001: 41)

2.7) The nature of the explanation

The structural description and understanding of music are thus important to both theory (pieces, styles) and psychology (the experience of music). In both there is a commitment to objectivity supported in various ways either by abstract formalisations or by experimental results. Cook argues, specifically in relation to theory, that this objectivity is illusory: "the theory of music is grounded in the experience of the individual, and for this reason objectivity is neither a feasible nor a desirable aim" (Cook, 1990: 243). The "experience of the individual" as such is, however, somewhat beyond the scope of psychology too, because this has focussed mainly on the universal characteristics of cognition in music and the hard-wiring of the brain, rather than the individual variations and the complex mix of factors that are an essential part of the individual experience Cook refers to.

When considering the experience of the individual (or individual cultures), Cook offers an alternative to the alleged scientificity of the explanations of music theory, which might apply for those of music psychology too, and which is that, in reality, any such explanations are of a mythopoetic nature “that takes place entirely within a culture: it explains things to culture-members in terms of culture-specific knowledge” (Cook, 1990: 242). Essentially he proposes to liken musical explanation to myth, whereby a culture understands itself and its present experiences according to the past ones, or at least to those that have acquired a paradigmatic value: “it is hard to imagine that any scientific study of musical productions could be viable which did not take into account the culture that gave rise to them” (Cook, 1990: 243).

Following this approach, the non-objective and unsystematic cross-over of experiences of foundational templates referred to earlier becomes entirely justified and in fact even necessary. Crossing experiential boundaries in any formalisation of musical templates is at the core a mythopoetic process, and this applies to both a collective (cultural) level and also to individual templates developed by analysts or composers for their own purposes. Moreover, if the mythopoetic approach seems to have merits to contextualise the explanation of music in theoretical and analytical models as well as psychological ones, it ought to have strength in the reversed mode of composition where, as initially stated, composers travel both from concrete details to abstract structures and also in the opposite direction in utterly individual ways. Mythopoesis gives a flavour of logic and of necessity, as well as subjective inter-connectedness, to these ways.

In composition, foundational templates more or less automatically, and more or less consciously, guide and ground the creative processes. They often exist before any musical theme and rhythmic idea take shape, and these are themselves eventually fine-shaped onto these templates as soon as they move from mind to paper, so to speak. Composers rely upon them as working tools, necessarily connected with, and expression of, their stylistic choices and aesthetic aims. The complex scenario of composition in the last hundred years has brought a proliferation of these templates into sharp focus (see Cross, 2003), and it is revealing to see them from a mythopoeic rather than a scientific angle, even if their initial impact is often the opposite.

2.8) The present approach

In this study I discuss the making of my own compositional templates both in the exploration of pc set 5-22 for the string ensemble piece *ed erra l'armonia*, and in the setting up of metrical hierarchies for the orchestral piece *Pneuma*. The main characteristics of my approach are:

1) The substantial adoption of traditional foundational pitch and rhythm templates. My work is more about layering and re-organising them at a higher level than challenging the baseline standard starting point. These well-developed practice-based theoretical/pedagogical templates for pitch and rhythm have been supported by psychology to a sufficient degree in my view.

2) The free use of models and tools from different recent theoretical/analytical templates as dictated by the material itself (e.g. Forte's pc set 5-22 developed according to Lerdahl's tonal pitch space theories).

3) The adoption of cognitive psychology theories concerned particularly with the principle of hierarchy, both 'tonal' and 'event'. Hierarchy is adopted here as one of the main cognitive and compositional parameters: cognitively in terms of the bottom–up processing of sensations and the top-down organisation of experiences; compositionally in terms of the detail-to-structure relationship and the structure-led-concretisation of musical material.

4) The reliance on Cartesian space as a means of representation and orientation of compositional and cognitive properties of the musical material itself, with a moderate use of numerical means. In doing so, my approach tries to apply simple logical considerations in the unpacking and networking of musical material. While helping this logic along, using numbers

also gives a special "charm" to the whole process. The fascination with pc set 5-22, for instance, derives in part from its abstract formal properties, not simply its musical ones.

5) The blurring of the three experiential boundaries of music theory/pedagogy, music psychology and music aesthetics in a heuristic, practical way that is similar to the heterogeneous nature of foundational tonal templates I referred to earlier. This does not rely on scientific verisimilitude, but on mythopoetic resonances, on the persuasive strength of my own personally selected myths, my subjectivised knowledge of a paradigmatic past.

3) A pitch-space for 5-22

3.1) A closer look at 5-22

There are several musical properties of 5-22 that can be investigated for its use in composition. First of all its structural properties, related to the presence of the four triads and to the nature of its constituent intervals.

The investigation starts indeed with these four triads because of their unmitigated impact on the overall set, both at sonorous, and also at an aesthetic level. This inescapably 'harmonious' nature of 5-22 is perhaps why analyses tend to ostracise it from the main structural harmonies of modernist music literature, but it is the very reason for its discussion and use in the present study.

As briefly indicated above, these triads are the four types described in traditional theory/pedagogy and based on the principle of the superimposition of the two types of thirds, M3 and m3. Thus we have a major (from the bottom: M3 plus m3), minor (m3 plus M3), diminished (m3 plus m3) and augmented (M3 plus M3) triad. The uniqueness of this aggregate has already been mentioned: not only does it have all the triad-types, but it contains them just once, being the most parsimonious set with this property, consisting of five notes; it can be called the all-triad pentachord. Interestingly, Carter calls a six-note set the "all-triad hexachord" (0,1,2,4,7,8), Forte's 6-Z17, a set that contains "all twelve three-note chords" (Schiff, 1998: 34), but these include three-note combinations well beyond the third-based triads.

Directly related to these four triads, there are two pitches that acquire a special structural role: these are pc0 and pc1 that can be seen as their roots (to use Rameau's inversional approach; see Rameau, 1971/1722: 40-41), even though the augmented triad (0,4,8) can claim that each of its three notes can have this role. Unfolding the triadic components of 5-22 in succession, it can be seen how the structural properties of pc0 and pc1 come to light, but also how a transformational cycle is created that connects the four triads within the set itself (Fig.4). These triads transform into one another with minimum semitonal voice-leading changes, determining a sense of priority among both the set's pitches and its harmonic connecting movements.

Fig.4, the four triads included in 5-22, preferred transformational pattern and pitch centres.

Lippius, writing in the early seventeenth century, talks about *trias harmonica* (in Bent, 2002: 569) as a perfect fifth subdivided equally in two thirds, and adds that depending on how the thirds are arranged, the *trias* itself can be "more perfect" or "less perfect", which is what we now refer to as the major and minor triads. Earlier Zarlino, describing the vertical arrangement of consonances that is a modern-day major triad (in fact giving particular care in its textural arrangement and doublings), says that its effect is "beautiful beyond words" (Zarlino, 1983/1558: 196). My approach to 5-22 somehow evokes both ideas, vertical sonorous beauty, and conceptual unity with internal fluid multiplicity, with the difference that to the two original categories of perfection two more are added that can be referred to as, for the sake of parallelism, major and minor 'uniformity' (augmented, two M3; and diminished, two m3). All this is to highlight how 5-22 is itself not just a sound-colour aggregate, but a fully articulate micro-harmony, a minimal but essentially complete exploration of triads.

5-22 is, overall, also a symmetrical aggregate because its pitches are positioned in mirror formation around a centre of symmetry that is pc4 (Fig.5). This pitch is also the only element common to all four triads, and therefore its structural role is of significant musical scope both linearly and vertically, and adds another possible set of priorities to the aggregate itself.

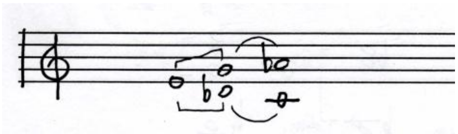

Fig.5, E as centre of symmetry of 5-22.

Considered vertically in its entirety, the set could also be arranged as a chord in tertiary fashion by repeating pc4 twice; in this way, pc1 would be found to be the overall root and its status as one of the main structural elements of the set would be reconfirmed (Fig.6). Repeating one pitch is not an orthodox procedure in this type of chord formalisation and indicates how this set consists of both symmetrical and asymmetrical qualities.

Fig.6, 5-22 arranged by thirds repeating the enharmonically equivalent E/F*b*.

Secondly the set can be studied according to its colouristic properties, which depend on the reciprocal disposition of the individual intervals when sounding simultaneously. Useful in this process are interval classifications, particularly dissonant ones, found in practical surveys of twentieth-century harmony. Křenek, for instance, distinguishes between “dissonances of lower tension degree or ‘mild’ dissonances: major seconds, minor sevenths, and major ninths” and “dissonances of higher tension degree or ‘sharp’ dissonances: minor seconds, major sevenths and minor ninths” (reported in Lenormand and Carner, 1976, vol.2: 68); Persichetti follows basically the same definitions (Persichetti, 1961: 14). Thus, looking at the iv of 5-22 [202321], it can be seen that the set contains none of the mild dissonances, two of the sharp ones and, the tritone, that owes its reputation more on account of its ambiguity than its degree of dissonance *per se*; the remaining intervals are consonances (both perfect and imperfect). Paradoxically, the two sharp dissonances, with their semitonal tension towards pc0 and pc1, enhance the impact of the two ic5 consonances, a case of melodic anchoring (Bharucha, 1996) to which I also refer later.

Both evaluations have followed a music theory/analysis and aesthetic path, but to this it is necessary to add a music psychology perspective, which somehow connects the colouristic (sensory) properties with those that acquire a higher cognitive persistence, and thus become structural. Particularly interesting here is the work of Huovinen that investigates tonal centricity, that is the perception of a “reference pc in a tonally perceived musical object” (Huovinen, 2002: xviii), and compares results and evaluations of relevant psychoacoustic experiments with notions of music theory and pedagogy. The novelty of his approach however is that he uses Forte’s pc sets and their ivs as the basic musical stimuli, therefore a rather abstract material rather than material that in its basic organisation is already more musically valenced (e.g. coming from diatonic, octatonic or non-Western scales), the use of which had instead been common practice in these studies until then (e.g. Krumhansl, 1990). This makes his work very relevant to me as I too, starting from a pc set from Forte, need to establish its structural characteristics not only from a theoretical stance but also from a cognitive and experiential one, upon which to unpack the set’s own compositional resources.

The presence in 5-22 of two ic5 intervals is particularly relevant. According to Huovinen, these “have a tendency to stand out from the melody and act as local TC [tonal centres] for the listener” (Huovinen, 2002: 325); the “ic5 intervals are inherently more ‘structural’ than ‘functional’ intervals” (Huovinen, 2002: 326) and as such lend stability to the experience of the set, and acquire an inevitable hierarchical predominance in listening. Importantly for this context, he also adds that, if we accept the notion of assimilating “tonal centricity to the greatest tonal stability in a hierarchy”, there is no obstacle in considering that any functions we might attach to a tonal centre could even “be fulfilled by two pcs at the same time" (Huovinen, 2002: 367). He refers here to the ‘root’ note of the two ic5s that, in agreement with practical music notions, he empirically re-confirms as the lower pitch for the perfect fifth and the higher one for the perfect fourth. He talks of melody, but his stance posits that, within the set, this multiplicity of centres might work harmonically too, not only for the two ic5, but also for their roots pc0 and pc1. In the case of 5-22, this points immediately to its inherent potential multistability, centred either on the ic5 C-G, or on the ic5 D*b*-A*b*. This aural multistability has, in fact, proven inescapable in composition unless guided by local musical events, for instance particular melodic shapes and voice leading choices. To describe these tonally interpreted pc structures, Huovinen introduces the notion of “pc constellations” (Huovinen, 2002: 51). Although the issue of tonality is of no concern here, his approach encourages a structural differentiation and possible functional use of these ic5s and of the triads based on them, and legitimises a fundamental link between sonorous and structural properties of the set in listening.

What matters most, therefore, is the way in which the intervallic content is musically aligned and projected into the foreground, for example through the reciprocal distributions of triads according to possible overall stability and hierarchy. This distribution would affect not only the sensory identity of the overall chord, but also its cognitive functions within phrases and structure of a piece (Fig.7). Conceptually, it should be noted that all ics included in the set would have legitimacy as ‘real intervals’ (as opposed to ‘added’, ‘passing’ or similar) and thus could be considered as structurally, if not sensorily, ‘consonant’.

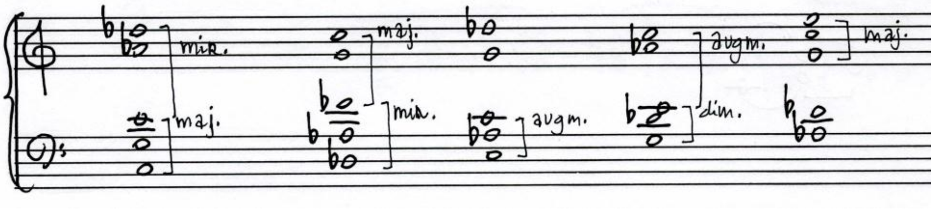

Fig.7, various dispositions of 5-22 indicating the position of the triads.

5-22 seems therefore to have not only fascinating formal properties and a striking overall sonorous identity, but also an intrinsic dynamism with multiple internal, well defined hierarchical structures according to various ways of unfolding the set. The next step in this exploration would be to consider a pitch-space that allows these properties to acquire their full expressive and technical power. In order to do so, one of the hierarchies explored so far needs to be considered (at least initially) as the more stable, and thus prominent one, from which the musical space of the set can be devised. This choice is an aesthetic one, but it is also informed by cognitive studies on music perception, for example Krumhansl (1990) and, as already seen, Huovinen (2002). In essence, even using different approaches and musical material, they both highlight the particular sensory and cognitive importance of ic5 and ic4, and give technical and artistic legitimation to the choice of making the major triad the more stable and thus hierarchically the central element of 5-22; this I believe opens up the possibilities of a richly articulated and satisfying musical space. While there might be some support for this in psychoacoustic studies, however, I am fully aware that the real issue here is one of musical treatment and presentation of musical material, and therefore it is through practical and aesthetic choices in composing that the priority of C-G over D*b*-A*b* can be more effectively pursued.

3.2) The morphology of the pitch-space

The pitch-space of 5-22 is built by applying concepts and models presented by Lerdahl (1992 and 2001). In the latter, these relate mainly to tonal music and triadic harmonies, with subsequent excursions into chromatic tonal spaces and atonal structures (including pentatonic, hexatonic, octatonic, whole–tone, free atonal and even venturing into twelve-note formations); they can however be also applied with significant results to a wider range of musical material. My particular application is suggested by the choice of structural hierarchy made previously, as Lerdahl’s strategy seems the most apt in addressing the issues of the triadic nature of 5-22 and of the prominent major triad within it.

A pitch-space is the representation of relationships among linked musical elements, such as for instance pitches and intervals. Two interrelated principles are fundamental to Lerdahl's space: hierarchy and stability. By hierarchy, as we have seen, "is meant the strict nesting of elements…in relation to other elements" (Lerdahl, 1992: 97); by stability is meant a specific non-reversible directionality of this nesting, in other words, the presence of one element at the centre of the system that attracts the other elements, as in a gravitational field. "Stability conditions are contingent on the basic material and properties out of which the event structure of a piece is made…and must operate on a fixed collection of elements" (Lerdahl, 1992: 108); this fixed collection defines the space. He adds: "there must be a strong psychoacoustical basis for stability conditions" as these are "relatively ineffectual unless they are supported by sensory consonance and dissonance" (Lerdahl, 1992: 109). Lerdahl's main objective is to develop an analytical tool, but he also legitimises the compositional use of the system, as he writes: "the theory presented here holds promise, both in its specific ideas and in its general approach of formal modelling in dialogue with empirical research, for future compositional practice" (Lerdahl, 2001: 381). I have already selected the stability criteria for 5-22 based on its theoretical, aesthetic and psychoacoustical properties; the task now is to make this chord the structurally more stable sensory element of a set of other yet unknown elements, with which it can enter into a dynamic and musically meaningful relationship.

Lerdahl's starting pitch-space is tonal and based on the diatonic scale (major or minor would simply depend on the specific context). In it there are five hierarchical levels which place, in succession from top to bottom and in an additive manner, the individual pitches of the structurally stable triad (the tonic): the root (level *a*), the fifth (level *b*) and the third (level *c*); the remaining pitches of the relevant diatonic scale (level *d*) and the twelve equal-tempered semitones (level *e*). This space represents pitch-proximity, in other words an upwards cascade of structural attractions towards increasingly higher degrees of hierarchy, from the diatonic scale to the tonic at the top (Lerdahl, 2001: 47-53). Lerdahl also uses this space to analyse (and measure) perceptual distances between harmonies (Lerdahl, 2001;

53-77), which he calls chord proximity both within the same key (region) or modulating (across regions), but this is not discussed here in relation to the space of 5-22, where chord proximity is evaluated by practical, sensory means and voice leading considerations.

In my application, Lerdahl's space is approached from the bottom up, on the assumption that pc0 of 5-22 is C. Level *e* is the twelve-semitone scale. The hierarchical properties of the space do not include this level, that appears musically only at associational level, a level where, in tonal music and in any other that makes similar distinctions, non-harmonic tones might be found (Lerdahl, 1992: 102).

Level *d* is a sub-set of the twelve-semitone scale, and functions essentially as the diatonic scale in tonal music. It is the scale with the minimum number of notes required to connect melodically the five pitches of 5-22 (following the principle of parsimoniousness) without leaving intervals greater than a major second (following Balzano's criterion of coherence, or maximal evenness; in Lerdahl, 2001: 50-51). These are important conditions in the musical management of octave-based scales found in the Western musical tradition, and are respected here, determining the minimum number of notes to be used: eight. It would therefore be an octatonic aggregate.

Interestingly however, the octatonic scale that is mostly used in composition and discussed in theory and analysis, made up of a regularly patterned succession of tones and semitones (pc set 8-28), is not obtainable in this pitch space; this would require either the substitution of G# with A, thus contradicting the basic pitch collection of 5-22; or the addition of A to the scale, thus contravening the parsimonious target of the set. In the latter case the resultant collection would consist of nine elements and thus be excessively chromatically saturated for the musical objectives of this particular exploration (see also 5.1). There are, however, two other possible non-standard octatonic scales that are given here not according to the pc set prime form, but in a form that contains 5-22 centred on C. They are:

a) C, D*b*, D#, E, F, G, A*b*, B*b*; pc set 8-26 (0,1,2,4,5,7.9.10) [456562]

b) C, D*b*, D#, E, F#, G, A*b*, B*b*; pc set 8-27 (0,1 2,4,5,7,8,10) [456553]

These two scales are extremely similar to each other, with only one difference: F or F# as the fifth element. The difference is small but it needs to be sufficient to enable a choice between the two. This choice needs further criteria, and these three are applied:

1 – The chosen scale would support the prioritisation of C-G over D*b*-A*b*, thus gently forcing the alleged equivalent psychoacoustic centrality of the two intervals within 5-22, and overall multi-stability of the set, in one aesthetically chosen direction. One way this can happen structurally is by favouring those pitches that stand in a melodic anchoring relation towards C and G, in other words those that are in "close proximity" to either of them and tend to resolve onto them (according to the principles of melodic anchoring, Bharucha, 1996).

2 - The chosen scale should fulfil as much as possible Balzano's criterion of uniqueness, whereby the ordered sequence of step-sizes, starting from each degrees of the scale, would yield non-duplicating patterns. This is considered an important psychoacoustic property of hierarchical pitch-spaces, and is found for instance in modes and tonal diatonicism.

3 - The 'diatonic' use of the chosen scale (meaning without additional chromatic alterations) should allow the greatest number of possible pitch sub-spaces that, when appropriately used, create momentary alternative hierarchical pitch structures. The scale should, in other words, allow successful internal challenges to the main harmonic reference sonority; it should make tonicisation possible by relying solely on the possibility of significant voice-leading alternatives to those that support the harmonic/melodic closure on C-G.

Scale a) is a symmetrical set arranged around E (or B*b*), from which it departs in contrary motion in inversionally identical patterns. This feature is the direct consequence of the symmetry of 5-22 and thus, while supporting triadic centres on C and D*b*, it can also potentially highlight E and Bb as important reference points for linear and vertical sonorities. Balzano's uniqueness criterion is respected, but the symmetry of the set creates some duplicating patterns between the prime scale and its retrograde. The multi-stability of 5-22 is also well supported. The centrality of the interval D*b*-A*b* is emphasised by ascending semitonal motion of a leading-note type from both C to D*b* and G to A*b*, justified both in music theory (voice leading) and in psychoacoustic studies (melodic anchoring). The centrality of the interval C-G, while acting as a local anchor but less prominently than D*b*-A*b* (for the simple fact that more chromatic steps stabilise on to the latter interval), comes instead from the emergence of a C-major diatonic flavour, with four pitches belonging to it (C, E, F, G). In addition to these two, however, the scale supports a number of other diatonic sonorities which are, on reflection, musically too assertive and stylistically too tonal (A flat major/F minor) for the role that 5-22 is to play in the pitch-space. In fact 5-22 seems a rather odd and arbitrary aggregate while D*b*, F and A*b* acquire, within the scale, a stylistically-informed psychoacoustic relevance that is stronger than C. Somehow, the three criteria are met but only in part, and in particular the features relevant to the third seem to limit the fulfilment of the first.

Scale b) is asymmetrical, and its prime and retrograde versions never duplicate the same intervallic patterns; it therefore fulfils Balzano's uniqueness criterion much more strongly. From this tone-semitone irregular distribution arise two interconnected, and partially contradicting, features: as asymmetry does not allow for a complete direct or inverted similarity of patterns in the scale, an overall tendency to hierarchy rather than equivalence in established. At the same time, the same irregularity makes some portions of the scale locally hierarchically ambivalent, thus allowing alternative voice-leading design and momentary shifting of the harmonic/melodic centre. These additional harmonic centres are not equivalent in scope, but exist within the overall centrality of the major triad of 5-22, and they can be projected by selective and specific use of the melodic properties of the scale, particularly of those ambiguous step-sequences. Moreover, the technical and expressive nature, and reciprocal relationships, of these centres and their voice-leading strategies are significantly specific and individual to reach beyond a simple tonicisation principle. They have the strength to create their own self-contained sub spaces within the overall pitch-space and ultimately attain their own expressive scope; they should therefore be perceived not as scalic fragments of it but as independent modes within it. These are modes of C major, of C# minor, of A*b* major, a pentatonic mode and a partial whole-tone mode. The centrality of D*b*-A*b* is asserted as in 8-26 and that of C-G is enhanced, through a similar anchoring mechanism, by F#

which lends a more subtle semitonal voice-leading support to melodic and harmonic closure on it. The three criteria overall seem therefore to be better fulfilled by scale b).

In choosing scale b) I emphasise the importance of ambiguity in its global and local patterns. This ambiguity, while allowing temporary challenges to the centrality of 5-22 driven by the same stylistically informed psychoacoustic principles as in 8-26, is far less explicit and assertive, and more in line with the idea of working with triadic harmonies than tonal triads.

Interestingly, in his discussion of the modes of limited transposition, of which the symmetrical octatonic scale (pc set 8-28) is No.2, Messiaen says that they are “at once in the atmosphere of several tonalities, *without polytonality*” and thus the composer is “free to give predominance to one of the tonalities or to leave the tonal impression unsettled" (Messiaen, 1944: 82). The arbitrary nature of these choices is supported by empirical cognitive studies, with Krumhansl observing that “the tonal and harmonic characteristics of the octatonic system need to be determined compositionally rather than following from structural properties” (Krumhansl, 1990: 277-278). In the asymmetrical scale proposed here, the composer needs to manipulate the space somewhat more deeply by carefully selecting its inherent structural properties for the “atmosphere” to shift from one mode to another, but a sense of poly-modality is more meaningfully rooted in its intrinsic structural possibilities.

The extended discussion of level *d* reflects its importance in the generation of a pitch-space that aims at establishing 5-22 as its centre in a way that is meaningful both structurally and psychoacoustically, and that generates musical material that both derives from and relates to this central set. This justifies using this rather unusual octatonic collection, which otherwise does not have an intrinsic self-justifying property (as the symmetrical octatonic scale does). However, the choice is not merely pre-determined by either music theory or music psychology, but by its conceptual and aesthetic impact: asymmetry and higher chromatic density around the two ic5s.

The next three levels up present 5-22 in a way that reflects the previous discussion of the structural and psychoacoustic properties of the set itself. It is important to notice that, while it might be possible to manipulate level *d* so that the centrality of C-G is as much as possible preferred over D*b*-A*b*, this might not be possible once the contextual elements of the overall pitch-space drop off as we move up the hierarchy. Lerdahl's original approach to a hierarchical octatonic pitch space (Lerdahl, 2001: 252) does not apply here, because his starting point is still a triad whereas here I need to accommodate a more complex pitch aggregate.

Level *c* presents the full set 5-22, with pc0 on C: the pitches are C, D*b*, E. G and A*b*. The way it relates to level *d* is clear, with the semitonal steps gathering around each of the pitches of 5-22, with the sole exception of B*b* that remains rather isolated and somehow neutral. The directional arrows indicate, as in Lerdahl's original model, "pitch proximity", a "path-like representation" of the distance and attraction of the elements of the space, leading up to the more stable elements of the structure (Lerdahl, 2001: 48-49).

For the next two levels up, the experiential evidence that gradually emerges in the compositional use of 5-22 corresponds to Krumhansl/Huovinen's position that the set might have two centres. Lerdahl's original pitch-space representation is designed to cater for one such interval, which for level *b* is the fifth interval (e.g. C-G) and one such pitch, which for level *a* is the central pitch (e.g. C). It needs therefore to be changed to address this new situation. A 3D modification is thus developed, where these two centres and relative perfect fifths are not in hierarchically subordinate levels, but lie on levels of equivalent importance. Two levels for each *a* and *b* are therefore introduced that run alongside each other, each hosting the alternative ic5s (C-G and C#-G#) and central pitches (C and C#). These two join at level *c*, the level of the common pitch E, where 5-22 is completed (Fig.8).

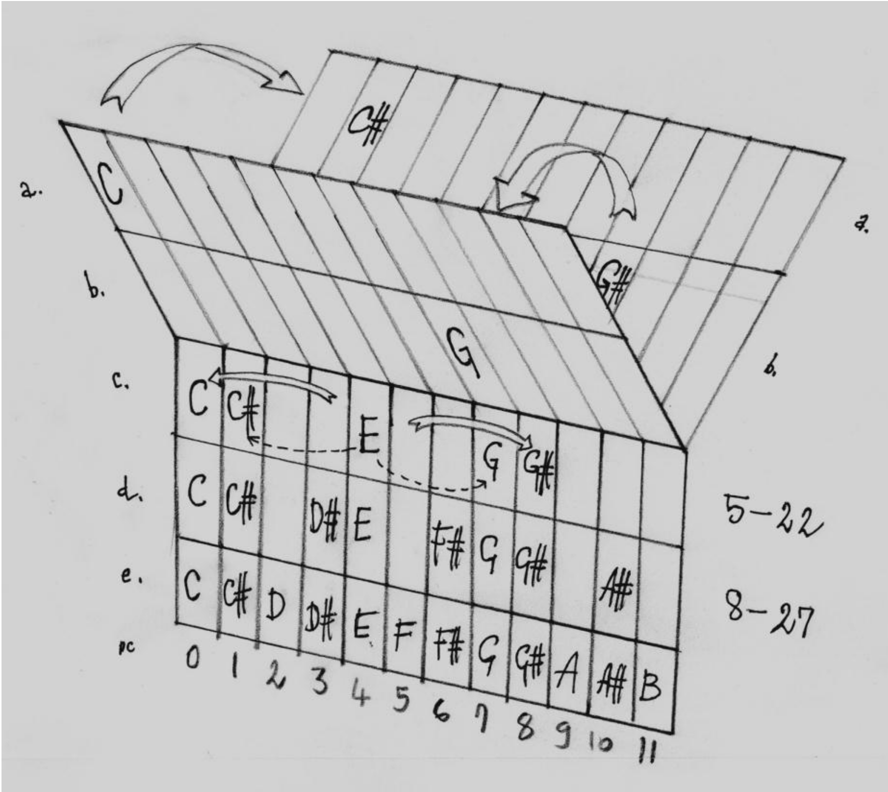

Fig.8, modified Lerdahl's pitch space for 5-22.

This modified space clearly highlights, again, the fundamental role of the minor second in supporting the two centres (indicated by the directional arrows in levels *a* and *b*). Huovinen's study suggests that, while a general application of Bharucha's anchoring theory might be questionable, the perceptual importance of such semitones movements in approaching from below the root of an ic5 reinforces the perception of it as the local TC [tonal centre] (Huovinen, 2002: 217). In exactly the opposite way, however, it is nearly impossible compositionally for G# (A*b*) not to support centricity on the fifth C-G, perhaps as a consequence of a stylistic voice-leading convention that is also psychoacoustically very powerful, that of the flattened-sixth semitonal descent towards the fifth of an ic5, a falling semitone that leads towards a resting place, towards a stable interval. A dynamic heterarchical relationship is thus created between the two centres that can only be hierarchically reconciled, as already mentioned, in the context of other compositional parameters, such as reciprocal distribution of pitches, voice-leading and thematic flow. Compositional experience with the set, both in terms of its sounding stability and its vertical intervallic disposition, also points towards the combined effectiveness of the simultaneous rise of semitone C-C# (as harmonic movement in the bass) and fall of semitone G#-G (as melodic movement at the top). This curiously suggests a kind of solidity of the ic6 C#-G, which in practice does acquire a special feel of neutral referential stability, perhaps on account of its un-committed status; a musically safe intervallic “non-allegiance” that, in the context of 5-22, echoes the importance of chromatic ambivalence in the choice of 8-27 versus 8-26. C emerges eventually as the top hierarchical element of this pc set only because of the overall pitch-space context; after all, the octatonic scale (pc set 8-27) is chosen with this final musical aim in mind, but the inevitable musical role of C# needs to be given, within the space, higher recognition. While the scale, therefore, hierarchically supports both 5-22 and its C major triad at the top, the specific hierarchy generated from 5-22 itself (culminating in either C or C#) can only be established by local musical features.

The following exploration of musical resources focuses on level *d* and applies to the choices made in relation to the string ensemble piece *ed erra l’armonia*; this exploration therefore representing only a small selection of possible options. A clarification is needed of the relationship between level *e* and level *d* in this particular context. Level *e* does not represent pitch at associational level active on a non-harmonic tones basis (as in Lerdahl’s original tonal space), but it does not as such compare at all in the piece. Any alteration introduced to the original octatonic scale means that the scale itself has been transposed (more on this later), and therefore those alterations in effect bring about a new level *d*.

The following examples show sub-sets of 8-27, presented in practical compositional terms, rather than analytical abstractions (Fig.9a-f). While the scale is notated in the usual stepwise, musically rather aseptic, ascending motion, the modes are presented in a shape that takes into account their individual musical nature. Sharps and flats are all enharmonically equivalent.

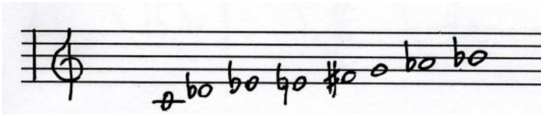

Fig.9a, the scale.

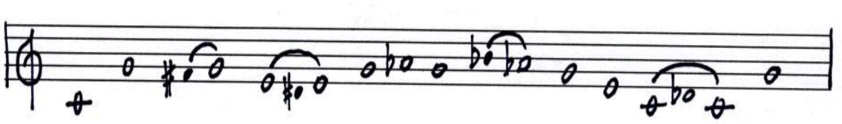

Fig.9b, a C major mode, the white notes indicate 5-22 (see bars 77-82 of *ed erra l'armonia*).

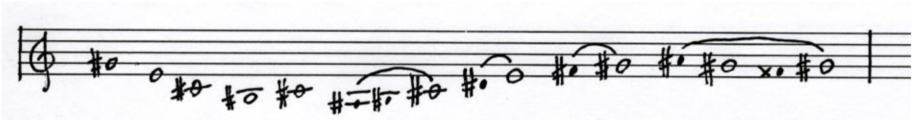

Fig.9c, a C# minor mode, the white notes indicate 5-22 (see bars 83-86 of *ed erra l'armonia*).

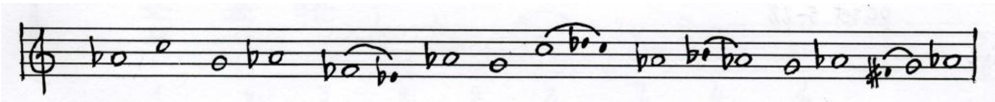

Fig.9d, a A*b* major mode, the white notes indicate 5-22 (see bars 87-90 of *ed erra l'armonia*).

Fig.9e, the white notes indicate the pentatonic mode.

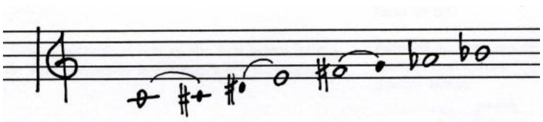

Fig.9f, the white notes belong to a whole-tone mode, the black ones belong to the other.

Harmonic sub-sets are generated in the following manner, which aims at reproducing the generative process of triads in a traditional diatonic context, normally starting from the tonic triad and moving up the steps of the scale. Thus 5-22 is placed at a chosen starting position on the scale and all five voices of the chord move step by step in similar motion along each of its degrees, generating seven more five-part chords before ending up on 5-22 again at the higher octave. These additional seven harmonies therefore represent a selected group of sub-sets justified by its derivation from 5-22, and supporting its special reference status. Following on from chord one (5-22), these seven chords are:

Chord two - (0,2,4,7,9) [032140]; this is Forte's 5-35, a pentatonic aggregate and the smoothest of the set because of the absence of minor seconds and tritones; this chord can be arranged by thirds as a V^{13} within a functional tonal space. In this context it represents an interesting contrast in terms of harmonic colour to other harsher ones.

Chord three - (0,1,4,7,9) [113221]; this is, following Straus, an instance of Forte's prime form 5-32. Carter, however, lists it separately from the latter (as number 38; in Schiff, 1998: 325), and this supports the experience that, in composition, prime forms might conceal musical characteristics that are of interest to composers. This chord includes a major triad and a major/minor one, and has a strong feel of stability which might even challenge the central status of 5-22. It is also a portion (gamma) of the Fibonacci-sequence-based chord that Lendvai calls the alpha chord ("type alpha has a strong tonal, even functional character"; Lendvai, 1993: 23).

Chord four – (0,1,4,6,8) [121321]; this is Forte's 5-30, a chord which can be arranged as a V^9 within a functional tonal space, without the third and with both a perfect and a flattened fifth. Again it represents an interesting harmonic colour in between Chord two and the others.

Chord five – this is a transposition of chord three.

Chord six – (0,1,4,5,9) [202420]; this is, following Straus, an instance of Forte's prime form 5-21, but in this compositional context only this embodiment is possible because of the scale pitch-constraints.

Chord seven – (0,2,4,6,9) [032221]; this is Forte's 5-34, a rather smooth sonority, which can be arranged, tonally, as a V^9.

Chord eight – (0,1,4,6,9) [113221]; this is Forte's 5-32 proper. Because of the presence of two minor triads its euphony is limited to only a few vertical arrangements of its pitches, and it thus requires particular resourcefulness in its use. It corresponds to one of Lendvai's portions of the alpha chord (portion delta), rather less stable than Chord three.

I consider these seven new chords conceptually as transformations of the original chord as it travels along the scale or, with a reversal of the motion image, as being 5-22 seen through an oblong bending lens (the scale) that moves gradually from one end to the other. In this way, we would witness 5-22 being stretched and transformed only to be gradually transformed back into the original when the lens/scale arrives at the opposite end of the cyclical process. Some elements remain constant, like the number of pitches, but others change considerably. This image echoes the conceptual approach to 5-22 as a gradual diachronic transformation of triad-types cyclically coming back to the starting point (discussed in 3.1). The following table puts this generative process in a format that focuses particularly on the iv of the chords (Fig.10):

Motion	Chords	ic1	ic2	ic3	ic4	ic5	ic6
	1 iv	2	0	2	3	2	1
	2 iv	0	3	2	1	4	0
	3 iv	1	1	3	2	2	1
	4 iv	1	2	1	3	2	1
	5 iv	1	1	3	2	2	1
	6 iv	2	0	2	4	2	0
	7 iv	0	3	2	2	2	1
	8 iv	1	1	3	2	2	1
Average iv		1	1.3	2.25	2.37	2.25	0.75

Fig.10, comparison of the ivs of the eight chords. The average iv is obtained by adding the eight values of each ic, and dividing the result by eight.

The result quantifies the overall impact of particular ics according to this particular selection of sub-set of 8-27. It indicates that these harmonies, when considered at this pre-compositional stage, carve out of the given scale a musical overall sound-colour that prioritises ics 3, 4 and 5, traditionally perceived as more consonant than ics 1 and 6, and also connected to triadic verticalities. It is a structural property of the pitch-space that corresponds to the compositional aim of exploring, through 5-22, the possibility of a triadic harmony at a more extended, but still exclusive, level. It is not an occasional triadic occurrence within an extended chromatic environment, but a foundational extended triadic base with occasional passing notes.

The examples below show 5-22 followed by the chords as they are generated along the scale, and in their more stable position following Huovinen's concept of "pc constellations", as was the case for 5-22 itself (Fig.11a-b).

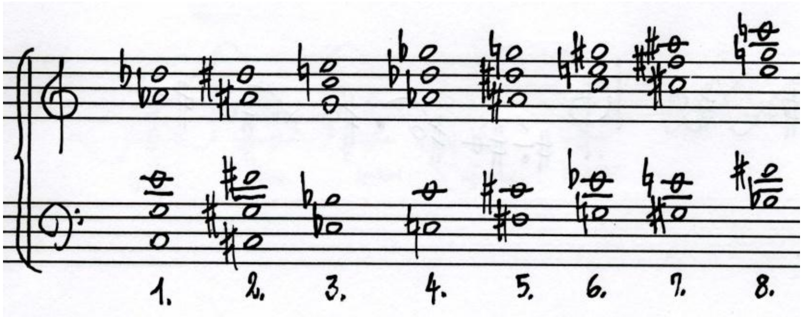

Fig.11a, the seven new chords (2-8) as derived from 5-22 and the scale

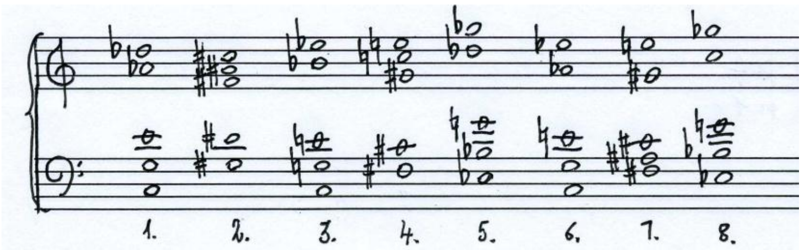

Fig.11 b, the chords in their configuration of greater harmonic stability.

If we follow the notion of the structural and psychoacoustic importance of the lower note of chords in their most stable configuration, certain pitches seem to become more prominent than others. C is by default the main one, being the foundation pitch for chords 1, 3 and 6. E*b* is important too, being the foundation pitch of chords 5 and 8. F# fulfils the same role for chords 4 and 7, and G# for chord 2. If we were to pick out the pitches for a bass line that sustains the most stable arrangement of the chords, we would therefore use C, Eb, F# and G#. For sure this would only be appropriate occasionally, as it is not varied enough melodically, but it might point towards the need to develop what Hindemith calls “an external special frame – a skeleton which gives the chords the necessary contour” for certain instantiations of this pitch-space, based on the two most prominent voices in the low and high registers (Hindemith, 1942:113). This is in effect a constructive principle similar to the gallant style’s *partimento dell’ottava* (see Cohen, 2002: 548 and particularly Gjerdingen’s schema prototypes, 2007: 453).

The pitch-space designed up to this point is now complete in its structural features. Its diverse and articulate elements stem from two processes that both start from the same central element. 5-22 generates the basic space and it also generates, by interacting with it, the remaining melodic and harmonic elements. It sets out specific tonal hierarchy conditions and also the operational boundaries for any subsequent event hierarchy.

3.3) The syntax of the pitch-space

What follows is an exploration of ways in which the elements in this space can begin to move, projecting and articulating their sonorous properties in time. It constitutes, essentially, the first step in the development of an event hierarchy that culminates in the completion of the piece itself. The discussion only considers harmonic factors at this stage, but clearly a richer spectrum of musical resources is possible when linear and vertical elements fully interact with one another, particularly the melodic and harmonic properties of the scale and of its modes discussed earlier.

The syntax is based on three processes: 1) transformation, 2) sentence building on the model of antecedent–consequent and 3) transposition. The first two are shaped by two factors. The first is that harmonic closure is directed towards the centrality and stability of 5-22. The second is that harmonic saturation (i.e. using the whole harmonic set, similar to chromatic saturation in 12-note music) is attained within important structural events (i.e. main closures). The interplay of the two guarantees that the result is not “cognitively opaque” (Lerdahl, 2001: 375-380), because closures on the central harmony give the music a clear “elaborational” rather than “permutational” structure, and the use of all eight harmonies would not psychoacoustically saturate the chromatic spectrum, as it uses only eight pitches of the twelve (see also section 5.3).

1 Transformation - There are two basic ways of unfolding the harmonies of the space, all derived from the basic interaction of 5-22 with the octatonic scale. One employs the simultaneous presence of all five sounds of the chords, thus imposing a 5-part real-note texture. The other breaks this simultaneity according to the specific sonorous components of the chords. In this second option, the chord is ‘stretched’ over time, but in a way that it maintains the consistency of the original set before alterations are introduced that are outside the

scope of simple non-harmonic tones. The real-part texture can thus be four or even three parts.

The first type includes:

a) Motion through the use of the chords as generated by the step-by-step movement along the scale, creating the sequence: 1-2–3–4–5–6–7–8. There is no other legitimacy for this sequence apart from the fact that it follows its original generative process and is therefore the most elementary presentation of the combined vertical and horizontal material (see Fig.11a-b).

b) Motion through the use of the chords according to minimum pitch change. Starting from 5-22, moving either by tone or semitone, the full sequence of chords is covered; this process creates the following sequence: 1–6–3-8–5–7-2–4 (Fig.12). Schönberg, quoting Bruckner, refers to this process as “law of the shortest path” (Schönberg, 1978/1911: 39). The concept of *parsimonious voice leading* also describes this procedure well; in this case, however, there is no implication in terms of neo-Riemannian functionality (see Cohn 1998a: 174).

Fig.12, the eight harmonies arranged according to minimum pitch change, the changed notes are circled (see bars 11-18 of *ed erra l’armonia*).

c) Motion through the chords according to the presence of invariant sub-sets, for example of the same major, minor, augmented and diminished triads, or more generally identical intervals or interval combinations:

- The eight chords arranged according to the common presence of augmented and diminished triads; Chord two is included for completion, but it does not contain either of these triads (Fig.13a).

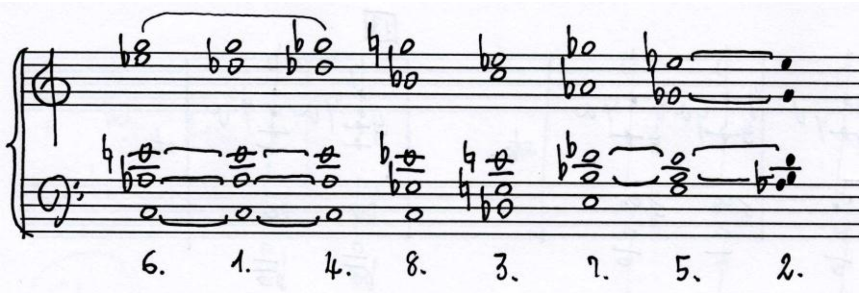

Fig.13a, the eight chords arranged according to the presence of augmented and diminished triads; chord 2 is included for completion even though is does not include either (see bars 24-32 of *ed erra l'armonia*).

- The eight harmonies connected through common major and minor sevenths. The sequence of the chord is the same as in the example before (Fig.12), but the two highlight very different harmonic qualities (Fig.13b).

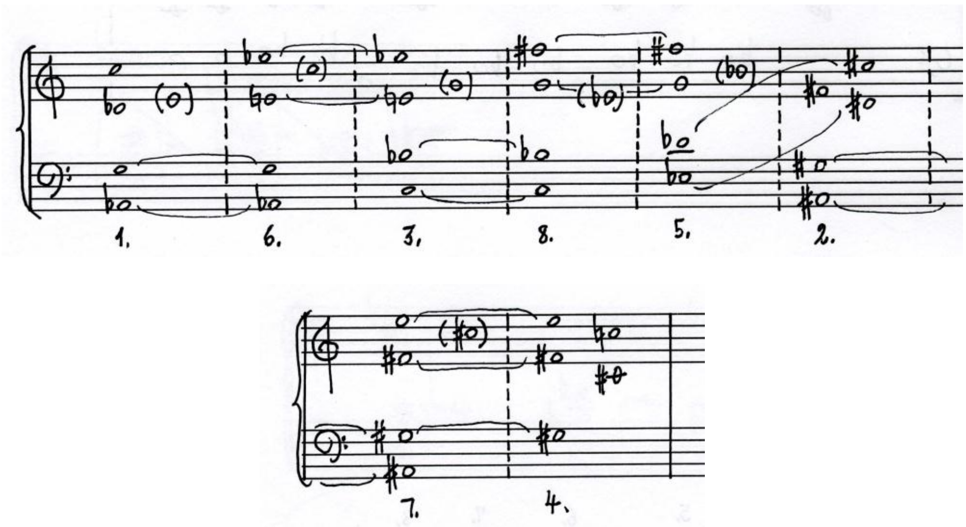

Fig.13b, the eight harmonies connected through common major and minor sevenths (see bars 55-63 of *ed erra l'armonia*).

d) Connections according to cadential movements towards 5-22, highlighting linear closure towards the most stable pitches of 5-22: C, E and G.

Fig.14, harmonic closure on 5-22 (see bars 101-112 of *ed erra l'armonia*).

The second type includes:

a) Chords 'stretched' over time to highlight seventh chords; most of these connections, while maintaining the option of closure on 5-22, can be defined as colouristic and somewhat circular in direction; the texture is mainly four-part (Fig.15).

Fig.15, the eight chords arranged as sevenths (see bars 47-54 of *ed erra l'armonia*).

b) Chords 'stretched' over time to highlight triadic harmonies; while maintaining the consistency of the original 5-note chords, the resulting harmonies can be arranged in ways that sometimes resemble tonal syntax (Fig.16).

Fig.16, the eight chords arranged in triads (see bars 91-100 of *ed erra l'armonia*).

From these examples, the space can be seen as generating and supporting material commonly considered as belonging to different stylistic musical environments (see 2.2). This is an important compositional feature that greatly enhances the sensory, expressive and structural scope of the space itself.

<ins>2 Sentence building</ins> - Sentences develop from the harmonic skeletons discussed so far, and generally consist of short tripartite structures, whereby the first two sections act as antecedent and consequent, and the third as a final statement leading in most cases to a clear closure on 5-22. In the expository phase of the piece *ed erra l'armonia* (bars 1-159), the introduction of each new harmonic transformation, linked to a new musical idea and figuration, is treated according to this model (Fig.17).

Fig.17, example of tripartite sentence structure, *ed erra l'armonia* bars 11-18;

slurs indicate the three sections.

<u>3 Transposition</u> - Transposition can be easily achieved by transposing the octatonic scale to each of the twelve semitones and obtaining the relevant chords. Since only the octave transposition reproduces the same pitches and there are twelve separate and different true transpositions of the set, the scale, as discussed earlier, is not a mode of limited transposition in the sense used by Messiaen.

However, the transposition process does not function as neatly as, for instance, with the seven-note diatonic major scale where, introducing progressively and according to a precise pattern the smallest intervallic change (one semitone), the greatest transposition spectrum is covered (the twelve semitones). In the case of 8-27, the smallest change needed to transpose the original set is two notes by a semitone each, but this creates a pattern that is locked into a cyclic repetition after only three transpositions, the note-pattern of the fundamental pitch producing a circle of minor thirds (for example C, D#, F# and A), outlining what in tonal terms is a diminished seventh chord (Fig.18). In order to access transpositions across all twelve semitones in this way, we need to create three different minor third cycles (the three different diminished sevenths that exhaust the chromatic space), but moving between these three is not an immanent property of the material itself. In order to set in motion a transposition process that covers all twelve semitones, three or four notes need to be altered chromatically. In the first case, with appropriate three-pitch changes, the C scale would be transposed into D, E, F, G, A*b* or B*b*, in the second case an appropriate four-pitch change would generate transpositions from C to B or D*b*.

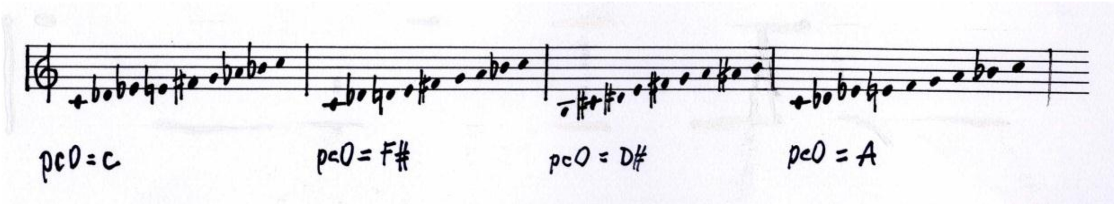

Fig.18, transposition of 8-27 according to the smallest change (two notes).

The relationship between these transpositions, if based on the property of the space itself, is thus not clear, as there is not a specific preferred path or directionality for going through the process, nor a clear sense of the outcome in relation to a hierarchical musical journey. If intrinsic musical reasons are hard to find, the transposition process certainly works in terms of increasing both the creative resources available to the composer, and the scope for prolongation of musical ideas, even if only following local voice leading convenience in relation to harmonic colour and thematic development or highlighting particular pitches across transpositional change (Fig.19).

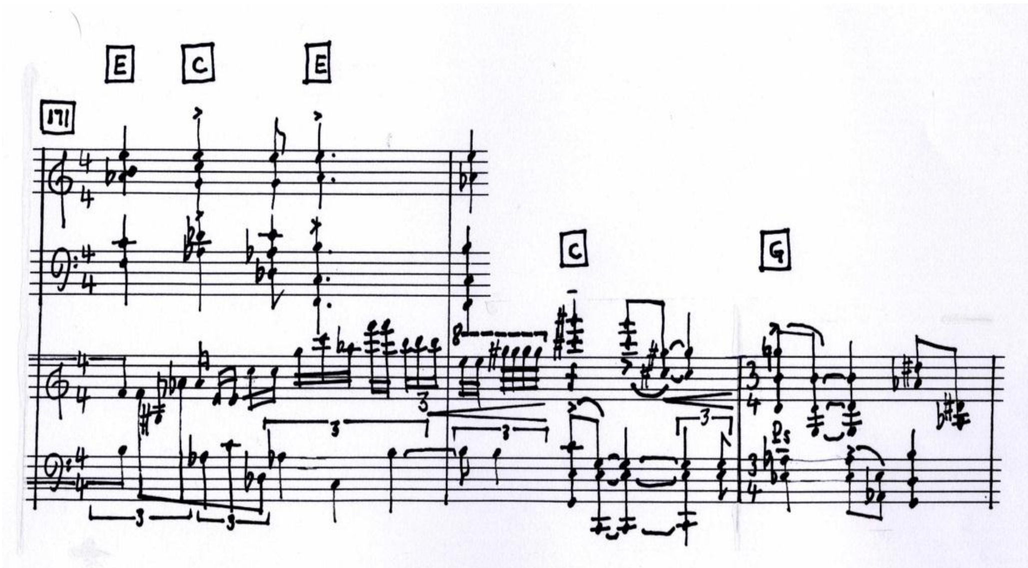

Fig.19, use of transpositions, *ed erra l'armonia* bars 171-173; the named pitches indicate the transposed pc0s of 5-22.

At this point, it is worth re-considering the issue of symmetrical and asymmetrical properties of musical material in general (for an interesting collection of examples see Hodges, 2003: 98-111). Hindemith observed that "in the domain of visual forms, symmetry is one of the most important principles of design; tonal and temporal phenomena, on the other hand, seem to avoid it" (Hindemith, 1942: 76). Considering Hindemith's preoccupation with a musical organization systematically built on first principles, his statement seems to support the idea that a hierarchical music space would require an asymmetrical relationship between its components. Schönberg similarly states that "the term symmetry has been applied to music by analogy to the forms of the graphic arts and architecture …real symmetry is not a principle of musical construction" (Schönberg, 1967: 25), though he recognises that mirror forms are the only ones that can be defined as truly symmetrical in music. Interestingly, Lendvai associates tonal music with asymmetry and atonal music with symmetry, stating that the tension between the two "became a seminal impulse in the development of European music" (Lendvai, 1993: 106). Lerdahl, talking about the representation of pitch relationships, notices that "western tonal music tends towards symmetrical grids but asymmetrical spaces" (Lerdahl, 2001: 287). In a recent study of Berg's music, Headlam suggests that "although procedures and transformations are based on symmetrical models, clearly the compositional units are not purely symmetrical in construction", and that by introducing additional elements to the symmetrical patterns Berg is able to maintain "the possibility and voice-leading implications of real, implied, or deceptive 'resolutions' of 'dissonant' non-chord tones" (Headlam, 1996: 62). Later on, he states: "Berg indicated in several comments and writings that he intentionally explored the tonal possibilities of his material" (Headlam, 1996: 199). The link between preserving the possibility of harmonic and melodic closure by distortion of the symmetry of the material, and exploring inherent "tonal" possibilities of the material itself is of great aesthetic interest for the composition strategies explored here. In fact, having accepted that asymmetry is an important feature of hierarchical musical structures, the initial pc set, the scale, the pitch space and the syntactical strategies proposed here have all been asymmetrically developed in order to achieve interconnection between a specific compositional/theoretical centricity and cognitive hierarchy. This therefore becomes inherent in the system and is, as far as possible, unambiguous regarding harmonic relations and voice-leading possibilities. In this sense, as a set of harmonic and melodic functions might start to emerge, this space could be defined as ‘tonal’, even if its morphology and syntax to not behave according to traditional functional tonal harmony.

4) Rhythm-space

In this section, I discuss the hierarchical organisation of rhythm with the aim of setting up a rhythm-space for the orchestral piece *Pneuma*. This space acts as a compositional template for the durational structure of the piece, in the same way that the hierarchical pitch-space of 5-22 acts as a template for the pitch organisation of *ed erra l’armonia*. In what follows I describe the process in stages and, as before, I refer at every step to data/concepts from both music theory and cognition. As before, the boundaries between the two fields are intentionally porous and elements of the two mixed.

4.1) The indifference interval and *Pneuma*’s main regular pulse

Psychological research on the experience of time points towards the existence of a duration-span (or *Interonset Interval* – IOI; the time that passes between two events) of around 600-700ms (MM = 100-80) that is of special interest. Fraisse (1982: 151-154) refers to it as both “spontaneous tempo”, that is the speed of some of our physical periodical motions (such as walking, breathing, the heart-beat at rest), and also as “preferred tempo” that is what appears to us to be the most natural of duration-spans in the perception or repeated time-events, one that we experience as neither too long or too short; this last is more commonly referred to as the “indifference interval” (see Clarke, 1999: 475; London, 2004: 31-32).

The convergence towards this value both of some of our own body motor and pulsation-periods and of our most cognitively comfortable perception of event-speed seems to be a significant feature of our experience of time. It would be of interest to see whether this has received any practical, conscious or otherwise, preference in musical composition (at metric or hypermetric levels), or has any practical impact on musical performance; certainly relating musical tempo to physiological periodicities was not untypical of both mensural and metrical music practice and theory up to XVII Century (see Houle, 1987: 3; London, 2004: 31; Caplin, 2002: 659). For instance, Houle reports that for Mersenne, writing in 1636-37, there seems to have been, at least in theory, a normative tempo equal to the second (MM = 60) that was seen to be somehow related, even if on the slower side, to the "body's pulse" (Houle, 1987: 5). This might point towards a practice-based notion not far, both in concept and in value, from modern time's indifference interval, and to a musical tempo related in some ways to it.

The rhythm-space of *Pneuma* starts from establishing a regular pulsation at the indifference interval (Fig.20). This is set at MM = 92, or 650ms, towards the high end of this natural experience of time.

Fig.20, the IOI a., at MM=92, within the indifference interval range.

4.2) The tactus and its duple and triple subdivisions

The regular pulsation discussed above can be better defined in music as tactus, which indicates the reference unit of duration in a piece. Historically, tactus was at the practical and theoretical foundation of the metrical system and an element of continuity with the earlier mensurality (see Caplin, 2002: 659-660). It was connected to the gesture of the hand beating the main musical measure (bar), comprising a down- and an up-motion (beat), and it was seen as an indivisible time-unit of the two musical phases of thesis and arsis ("ebb" and "flow", see Hasty, 1997: 22), each of which could be of equal length (i.e. short-short, 1:1, a binary division) or unequal length (i.e. long-short, 2:1, essentially a ternary division), in this also inheriting the *perfect* and *imperfect* mensuration practice and theory of medieval music (see Busse Berger, 2002: 628, 645; Caplin, 2002: 658-661; Hasty, 1997: 22-26). Interestingly, as early as 1627, both down- and up-beats could already be subdivided in two, making up a fourfold tactus unit (see Houle, 1987: 9), that in modern time would correspond to a 4/4 time signature.

These historical aspects of musical practice/theory seem to find resonances in modern psychology of time and of music. In the study of rhythmic and arrhythmic tapping, Fraisse found the 1:1 ratio as one of our most frequent spontaneous patterns (Fraisse, 1982: 165), strongly linked to some of our body's movements and functions (see Clarke, 1999: 474). He also found that, specifically in rhythmic tapping, another spontaneous pattern emerges, made of two durations in the 2:1 ratio, that he calls *temps longs* and *temps courts* (Clarke, 1999: 474-475). These ratios are the same as those of the subdivisions of the tactus, with the difference that his approach considers sequences of successive events rather than divisions within the events. Other experimental results, however, confirm that a "beat interval" can be "filled" in three ways: empty, two equal subdivisions (1:1), and two unequal ones as long as they are related in a 1:2 ratio (Povel, 1981: 17). Therefore we see established in psychological terms the two main ratios of 1:1 and 2:1 (or 1:2, the difference is somewhat relevant, the first one being preferred by music theories too) both as additive pulsation patters and as subdivisions of the pulse itself.

The practice and theory of the musical tactus, fluctuating it seems from earlier references to 'measuring' time ('misura', bar), to currently meaning 'beat' in a bar, seems to comprise both these parameters, whereby the bar is made up essentially of binary or ternary additive groupings of beats (ref. Fraisse), and each beat can be subdivided in the first instance into *perfect* or *imperfect* proportions (ref. Povel).

The regular pulsation at the core of *Pneuma*'s rhythm-space is also a tactus, both as measure (bar) in its fourfold subdivision (essentially a 4/4 bar, the time signature of the piece), and as beat. In fact, the subdivision properties of the tactus-bar are transferred to the tactus-beat that is thus intended as a unit of the two essential down-up (ebb-flow) gestures, made up either of binary or ternary sub-values (1:1 or 2:1 – more often as 1:1:1) or indeed ‘empty’, in other words undivided (Fig.21).

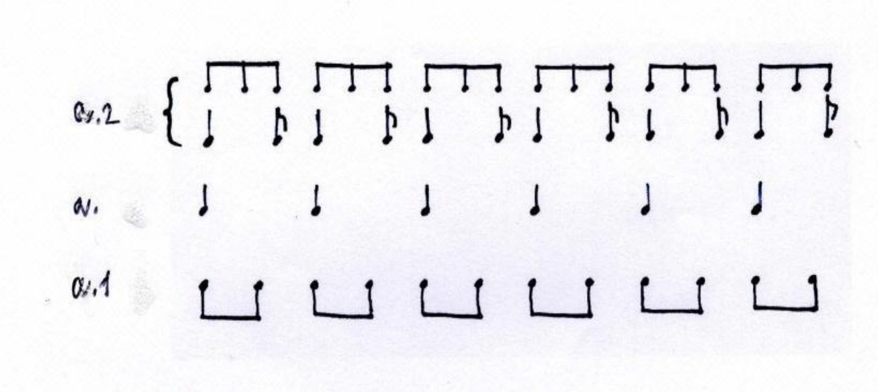

Fig.21, *a* is the empty tactus, *a1* with 1:1 subdivisions, *a2* with 2:1 subdivisions (1:1:1).

4.3) Subjective rhythmization, metrical envelope and the generation of faster and slower tacti in *Pneuma*

The notion that, when musical events happen too fast or too slow, the mind finds it difficult to extrapolate a sense of structure or order/relation among them is a well-known one and has been successfully exploited in composition, for instance by Ligeti (the very fast notes in his micropolyphony; see Griffiths, 1989: 26) and Feldman (the very sparse and slow events sabotaging memory functioning; see Snyder, 2000: 254).

This too fast/too slow range of pulsation-speed has been extensively studied in psychology. Fraisse refers to it as the range where *subjective rhythmization* is possible, which spans from 120ms (500bpm), the psychophysiological limit for distinction between two successive stimuli, to 1800ms (33.3bpm), when two stimuli are not any longer perceived as linked together (Fraisse, 1982: 156). He also indicates the longer range 2–5 seconds as the one where a more organised apprehension of musical rhythmic pattern happens (Fraisse, 1982: 171).

London approaches this notion in two ways. He firstly talks of metric entrainment, when our perception of rhythms latches onto temporal invariants (London, 2004: 25) and that is possible from values of 100ms to about 5-6 seconds, which he refers to as the “temporal envelope” that contains a range of phenomena from basic rhythmic ordering to hierarchical integration of events (London, 2004: 27, 46). Within this, he subsequently indicates the sub-range of 250ms to 2 seconds (MM = 240–30) as the ideal range for grasping a sense of beat or tempo, a “metric envelope” where, going beyond the basic process of *subjective rhythmization*, it is possible to integrate rhythms in complex hierarchical levels (London, 2004: 46). The value of 250ms, or JND (*Just Noticeable Difference*, a measure of perceptual acuity), acquires a special status, being the fastest pulsation-speed that still gives a sense of latent possible subdivision which, he claims, is crucial for the understanding of a pulse as a musical beat (London, 2004: 46).

London develops a graphical method to represent the various temporal thresholds of this metric envelope through basic means of musical metre/rhythm theory and notation (London 2004: 42). Starting from a central tactus-beat of 650ms (MM = 92, the indifference interval) he divides this unit into shorter durations (both duple and triple subdivisions), or he groups it into larger patterns (the unit as a subdivision of higher order rations of 1:1 or 2:1; whereby a crotchet would be intended initially as a beat in a 2/4 or a 3/4 bar), building up a metrical grid that shows what he refers to as the different depths of “metric entrainment” (see London, 2004; 17). Interestingly, his notion of a threshold between the possibility, or not, of latent subdivisions of the beat seems to point to a distinction between a hierarchical and an associational perception of rhythm. Beyond this threshold, we tend to understand events by grouping them together (association), while within it we tend to perceive these as potential higher level unified entities (hierarchy). His 250ms–2 second range is where each duration event can be experienced in both ways: bottom-up grouping and top-down subdivisions.

This distinction is not dissimilar to what Fraisse observes in the perception of *temps longs* and *temps courts*, support for which comes also from an aesthetic evaluation of specific musical contexts from a range of composers (Fraisse, 1982: 170-174). He notices that the short-time does not have perceptual duration and tends to be apprehended in an additive manner (two and more together: association), whereas the long-time has real duration and lends itself more spontaneously to being subdivided in twos or threes (hierarchy). Fraisse attaches range values in milliseconds to these two time categories (respectively 180-280ms and 300-900ms), with a clear threshold of perception change at around 280-300ms (not too far away from London's 250ms, JND); however his aesthetic approach seems to suggest that specific musical contexts have a strong impact on this perception and, in practical musical terms, *temps courts* could be in effect quite slow, and *temps longs* relatively fast.

Pneuma's rhythm-space is essentially based on London's graph and develops both faster and slower levels of durations that grow out of the indifference interval central periodical pulse. It uses both the concept of sub-divisible duration of *temps longs* and of additive regrouping of *temps courts*. Each tactus-beat of the basic 4/4 bar is considered a *temp long* and sub-divided into two or three events, considered as *temps courts*. These are then regrouped together in such a way as to form two new tacti (two new *temps longs*), a slower one (3/2 of the original one) and a faster one (2/3 of the original one) (Fig.22). Each of these is in turns subdivided into two or three events (duple and triple subdivisions), one of which for each corresponds, of course, to the earlier subdivisions of the original tactus. Three tacti emerge from the process: the original one (middle-tactus, crotchet at MM = 92), a slower-tactus (61.3bpm) and a faster-tactus (138bpm) (Fig.23a, and 23b).

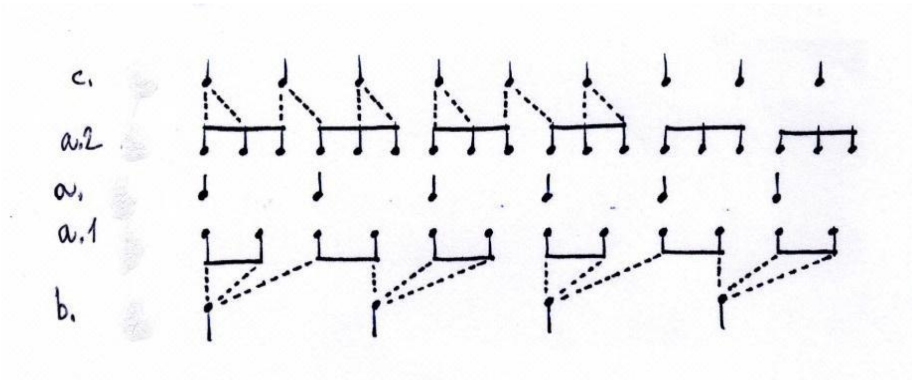

Fig.22, the tactus subdivisions in *a1* regroup into *b*, a slower tactus (3/2 of *a*); the tactus subdivisions in *a2* regroup into *c*, a faster tactus (2/3 of *a*).

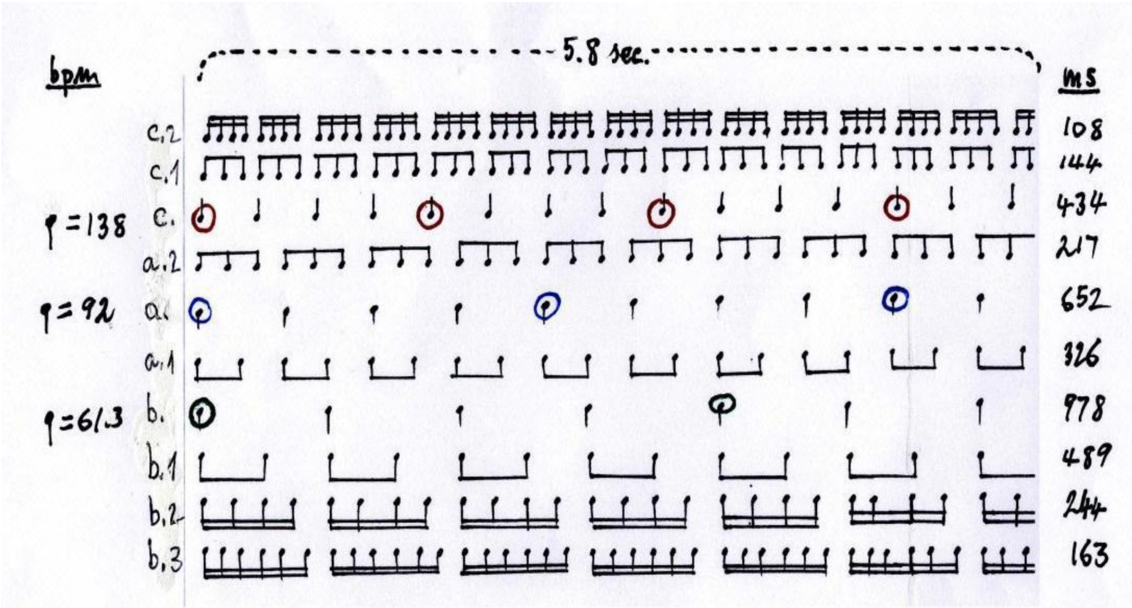

Fig.23a, a temporal envelope where all event-durations can be apprehended structurally. The space covers from IOI 108ms (*c2*) to grouping structures up to 5-6 seconds; the decimal points in the ms values (on the right of the template) are not included. The starting level is the tactus *a* at crotchet = 92MM; *b* is the slower tactus (3/2); *c* the faster one (2/3). Circled beats represent a quadruple ebb-flow structure (blue is the central tactus, dark green the lower and red the faster). All beats subdivisions and re-grouping are derived from the central beat, using 1:1 and 2:1 (1:1:1) relationships. The notation is not to be read as compatible across the three tacti, but only within the *a*, *b* and *c* groups.

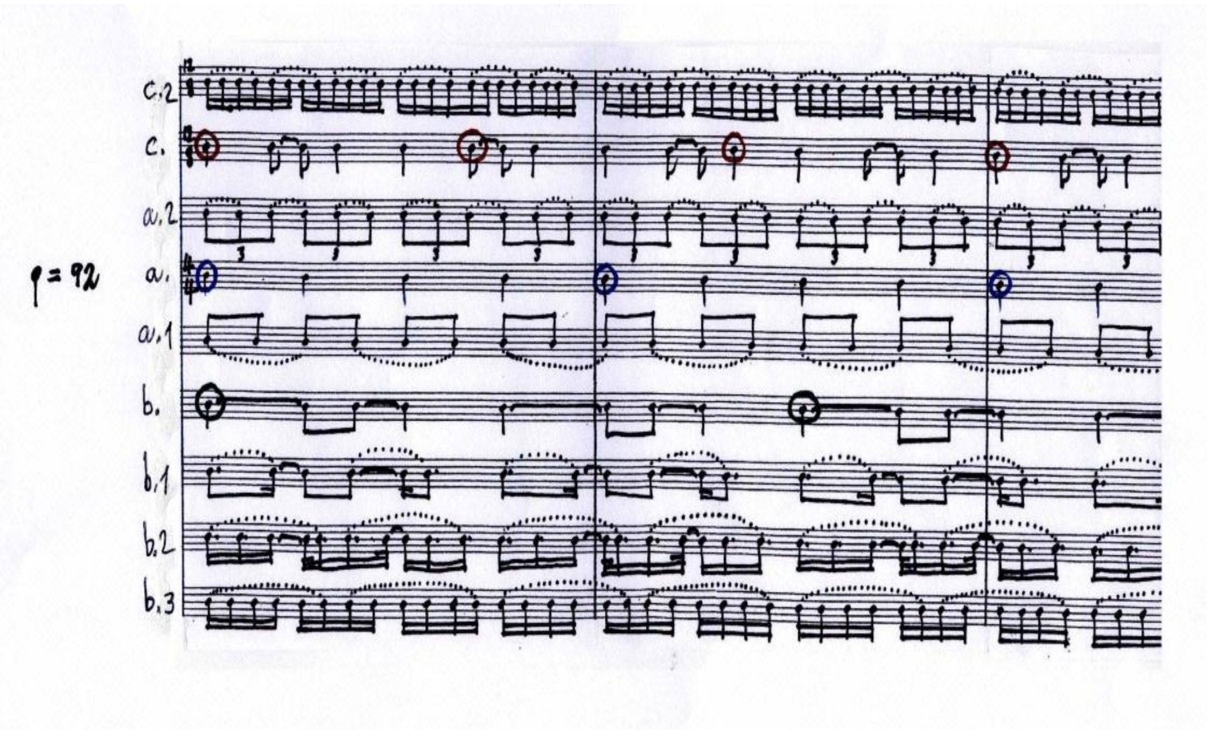

Fig.23b, the same temporal envelope translated into the rhythm-space of *Pneuma*. All notation is related to the 4/4 at crotchet = 92; not all subdivisions in Fig.23a are used in the piece but all structural rhythms in the piece are derived from durational values in this space, a part from very few exceptions that utilise *c1* of 23a.

4.4) Further considerations on the space

4.4.1) I have called this space a rhythm-space because, eventually, its immediate presence is going to be felt through the surface rhythms of melodies, harmonies and timbral changes of the actual piece. It ought to be called, however, a metric-space, because it sets up a pre-set grid of durational relations upon which rhythms are compositionally generated. Despite arguments put forward that reject the notion of rhythm and metre just used (i.e. Hasty, 1997), this approach points to a practice that is still useful in composition and that does not necessarily limit more nuanced approaches.

The relationship between the metrical grid and the rhythmic surface is essentially negotiated through the musical means of accents, intended not as expressive tools in performance, but as events of change/addition to an otherwise homogeneous musical flow (thus, for example, at the most minimal and local levels, I would consider it an accent when a melody moves from one pitch to another).

Following Lerdahl and Jackendoff's description of three types of musical accents (Lerdahl and Jackendoff, 1983: 17), and turning their analytical approach into my own poietic one, the compositional process is constantly engaged in distributing and synchronising phenomenal, metrical and structural accents so that there is an alignment of musical duration surfaces with the underlying metrical grid according to the developing musical design.

All accents are phenomenal in the first instance; they are all the events that shape the musical surface. A selection of those among them that are (or are linked to) periodic re-occurrence becomes metrical and is tied onto the metrical grid; these accents correspond to Lerdahl and Jackendoff's *beats*, organised hierarchically in metrical structures. A further selection, which might (or might not) correspond to the metrical selection, becomes structural at points of musical gravity, of important melodic, harmonic or timbral events in the piece where higher levels of musical articulation happen (typically at a hypermetre level of a few bars, and corresponding often to musical phrases); these accents mark off what Lerdahl and

Jackendoff call musical *units*, and are organised into "grouping structures" (possibly hierarchically; Lerdahl and Jackendoff, 1983: 25).

Although their approach was developed for analysis of tonal music, there is no reason why a similar process could not be relevant in other stylistic contexts too. In my case it applies as a compositional tool to each of the three tacti, and generates both individual and overall hierarchical metrical and grouping Gestalten (see London, 2004: 17 for the use of Gestalt in relation to metre) (Fig.24a, 24b and 24c; Fig.25).

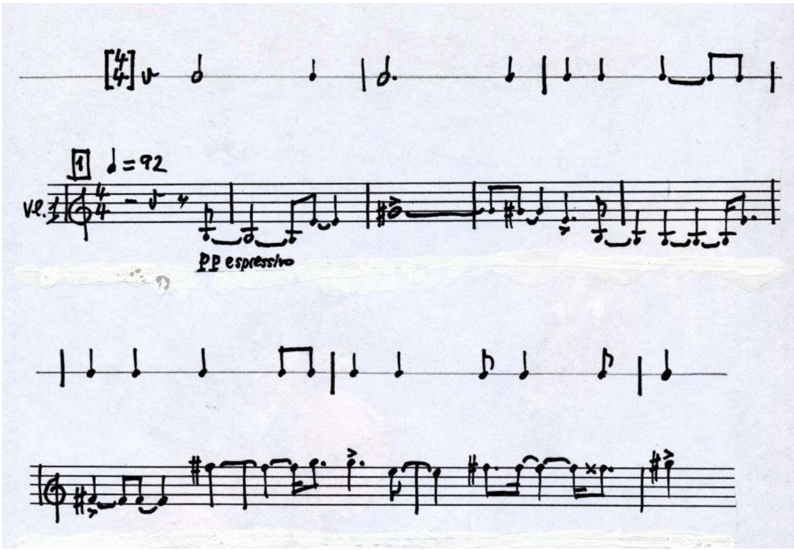

Fig.24a, phrase based on the slower tactus at the very beginning of the piece. The line above indicates the actual rhythm and its metrical organisation (*Pneuma*, bars 1-9).

Fig.24b, phrase based on the central tactus and corresponding to the actual metric notation. The line above indicates a possible metrical hierarchy that would imply a 3/4 metre rather than the 4/4 of the time-signature (*Pneuma*, bars 11-14).

Fig.24c, phrase based on the faster tactus; again, the line above indicates the actual rhythm and its metrical organisation (*Pneuma*, bars 25-30).

Fig.25, the rhythmic organisation of this short passage (and a few others similar to it) combines the three tacti as indicated above, in a structural crescendo of speed (*Pneuma* 257-260).

4.4.2) The rhythm-space presents three tacti that are musically treated both as inter-related and as independent from each other. In a sense, the nature of their relationship is one of 'metric modulation'. This normally refers to music where a rhythm pattern remains constant as its metrical context changes (Lester, 1989: 24).

In my space, the elements of perceptual continuity through the modulations are these inter-related durational values that are mostly overlapping across the three tacti (Fig.26). What changes then is the way they are metrically organised, following the hierarchy of the locally leading tactus. These modulations are both sequential and layered onto each other, with all three structures sometimes present simultaneously.

Fig.26, two tacti modulate in-and-out of one another. The two lines above indicated the main metric relationships. The lower dark green line is the slower tactus, the higher blue one is the central one (*Pneuma*, bars 74-82).

Throughout the piece, the conductor's gesture, following the unchanging time-signature, is always locked to the MM=92 of the middle tactus and does not change for each new modulation. This constitutes a further element of continuity, albeit a visual one, and gives to this level a perceptual advantage over the other two, as the fixed visual clues contribute and also interfere with changing auditive ones. The idea is that, despite these conducting clues, the other two metric levels will emerge in the experience of listeners and watchers purely on musical terms through the establishment of different metric accents, through auditory properties rather than visualised spatialisation (which applies to both a score and a conductor's beating).

In this sense the piece, despite the strongly schematic approach to metre in the compositional phase, adopts Hasty's hypothesis that, in perception, the experience of metre is not an abstraction that is detached from rhythm and that organises it (Hasty, 1997: 3-10), but is essentially a projection ("throwing forth" into the immediate future) of potential duration patterns (rhythms) based on those experienced immediately before (see Hasty, 1997: 84). For him, metrical accents that are normally defined as strong and weak time-points (e.g. first and second beats), are instead perceived as musical beginnings and continuations (Hasty, 1997: 104), therefore having durational and qualitative aspects dependent on the developing musical context rather than being spatialised, non-durational and instantaneous. Likewise, hierarchical structured relations are perceived as real-time experiences of analysis/division and synthesis/multiplication (Hasty, 1997: 115).

What is crucial in his approach is the emphasis on the durational nature of the musical experience and the constant evaluation, comparison and prediction of its parameters during it, rather than the application of pre-set structures. The metric modulation events in the piece (both linear and layered) against the constant visual clues that might at time support and at time contradict them would force the listening and performance processes to tune-in constantly to this local evaluation and predictive efforts. It is a scenario of constant playing-off between Imbrie’s conservative and radical hearings, where in the first case listeners try to “retain the previous pattern as long as possible against conflicting new evidence” and in the second they “immediately readjust according to new evidence” (in Lerdahl and Jackendoff, 1983: 22-23) (Fig.26).

4.4.3) In terms of both composition processes (and thus the application of analytical and theoretical resources) and perception and understanding in listening (and thus the cognitive parameters of musical experience), the rhythmic/metric organisation of the piece is kept intentionally as much as possible transparent. A part from composing the actual surface details of the piece in this way, the space itself is pre-planned to support this transparency. This is done in three ways.

The first is the hierarchical structure that vertically synchronises at regular duration-intervals the main tacti and their subdivisions and groupings described above. This is rather straight forward in its basic functioning and does not undergo any significant exception in the piece.

The second is the delimitation of the extension of the rhythm-space open to compositional exploitation within the cognitive limits of temporal experience. This delimitation covers, in the long duration-span, 5–6 seconds (perceptual present), that correspond at slow-tactus level to one and a half bars, a moderate hypermetric span within which nearly all rhythmic gestures in the piece are contained. In the short duration-span, at the fourfold subdivision level of the fast-tactus, it corresponds roughly to 109ms, the fastest structurable speed of events. The few cases of faster figurations in the piece are connected to music surface decoration, musical colour and gesture, and thus escape *subjective rhythmization*. The middle-tactus comfortably sits nearly entirely within London's metrical envelope, with the fastest subdivision at 217ms (almost the JND), and the full level of metre at 3.8 sec (one bar).

The third is the maintaining of a high level of synchronicity. There is concordance between the metric structures (the beats arrive periodically together) and the grouping structures (the phrases peak more or less together) of the music material of the three tacti. Both within each, and among the three, there is a high number of structural events that are temporally coordinated (Fig.27); in practice the structural downbeats of the three are together at regular intervals, and phrases often coordinate with these too (see section 5.1).

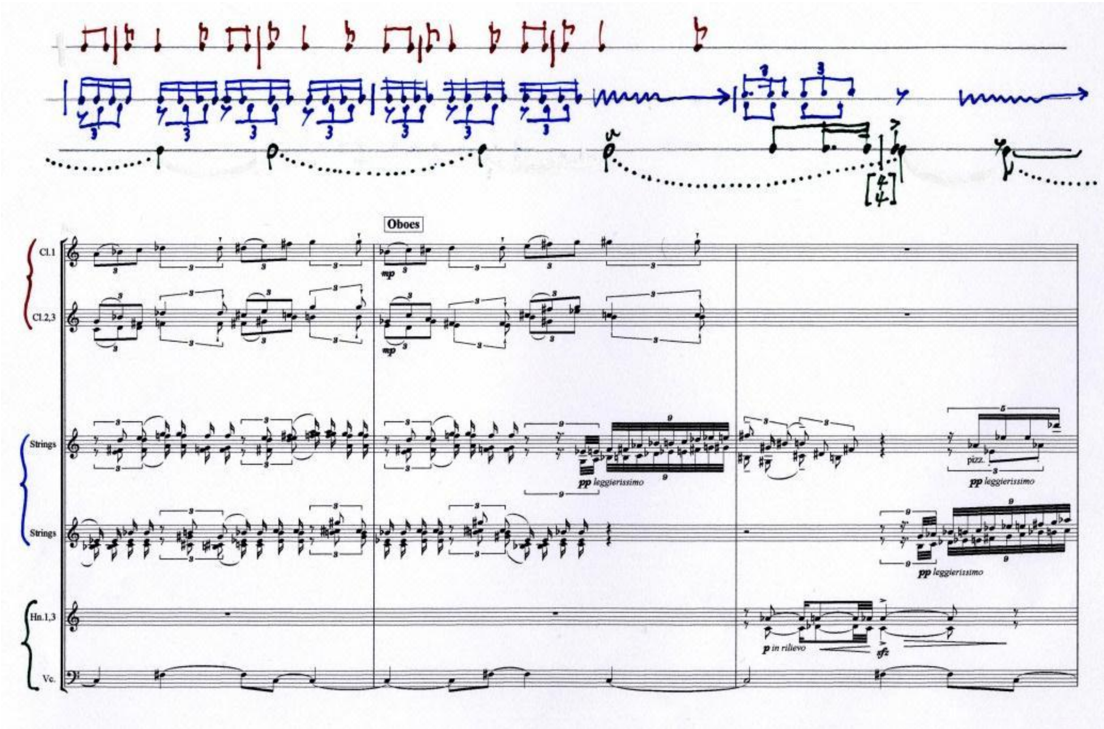

Fig.27, the layering of the three tacti. Not all sections of the score are shown, but only the main ones that carry the rhythmical organisation. The slower tactus (lower lines, in dark green) is not interpreted metrically at the beginning, and only in bar 8 it acquires a clear ebb-flow pattern with the arrival of another figuration. The wiggly lines in the middle tactus (nonuplets) represent a level of rhythm that is expressive and colouristic rather than structural. What is structural is the overall effect (*Pneuma*, bars 311-321).

4.4.4) I have built my rhythm-space by starting from the indifference interval and by proceeding down-wards into faster subdivisions and up-wards into slower groupings following general consensual elements and processes of both music theory/pedagogy and music psychology.

Compositionally, from somewhere in the middle of the tempo range, I ended up with three overall broad areas of musical rhythmical resources. These are related to the tacti in two ways; each of the tacti has its own theory and cognition-based hierarchical tripartite space: normal, subdivided and grouped; but also the three combine together to create an overall space covering in tripartite fashion the full range of the perceptual experience of time: the spontaneous tempo, the shortest limit of *subjective rhythmization* and the widest span of perceptual present.

Clarke notices that middle levels of time organisation and perception have been a common starting point both in the theory and in the psychology of music (Clarke, 1987: 221), and it is inevitable perhaps to ask if there is also such middle-level in the process of musical imagination, a compositional spontaneous entry-pace at which musical ideas come, that corresponds to the same theoretical/psychological middle range and from where it is possible to conceive and explore both faster and slower designs.

Clarke links the temporal structure of music (an approach he claims typically taken by analysis and theory) to the relevant cognitive representation of the experience of musical time (both in perception and in performance), and argues for three levels of correspondence: a middle-level, a low-level and a high-level. Even if not specifically to do with tempi and speeds of musical events, there are interesting parallels between this and my own doubly-tripartite compositional space. In attempting a synthesis between the two, the tempi of the tacti can be seen as corresponding to Clarke's middle-level, where both rhythm and metre can be treated with both maximum compositional resources (in subdivision and grouping) and maximum perceptual comfort. The slower pace of hypermetres (larger-grained events) corresponds to his high-level, where issues can be found of musical form in composition and of heavy engagement of memory processes in cognition. The fast subdivisions (finer-grained events) are his low-level, where the focus of composition is nearly entirely on the local musical gesture at a phenomenological accent detail, and musical apprehension is captured largely by the immediacy of compositional nuances that have an expressive rather than durational effect (see Clarke, 1987: 233).

4.5) Some observations on metre in modern art-music

I started by setting up a rhythm-space and have ended up concentrating on metre. My approach has been a compositional one combining elements of theory/pedagogy and of music psychology. It is worth now considering briefly the relationship of rhythm and metre in the context of twentieth/twenty-first century composition because, while rhythm has been a hugely rich and successful field of exploration, metre has been approached with some ambivalence, particularly by what is normally referred to as art-music.

A useful and maybe unusual perspective for looking at the symptoms of this ambivalence, and from which some of its deeper causes can be hypothesised, is the use of music notation. Notation is part of a communication process between composer and performer, but also between composer and him/herself, and it contains significant traces of compositional personal thinking within the context of shared practical and conceptual parameters. The starting point is the traditional practical and unproblematic relationship between rhythm and metre in notation itself, that is expressed and regulated through codified subdivision and repetition arrangements of durations at beat, bar (grouping of beats) and hypermetre (grouping of bars) levels through the use of time-signatures. Metre thus, notationally, is a pre-set grid for measuring and structuring duration patterns, into which rhythm is slotted and around which it is developed. It is hierarchical, because reducible to pyramidal top-bottom durational relationships, and spatialised, because it uses properties of space and numerical proportions. By seeing and managing space, a composer can understand, control and shape duration; this relationship is directed through a straight forward *quantitative* time-span template.

This basic conceiving/visualizing and writing convention however comes with another traditional, over-learned and implied notion: that of the measurement of *qualitative* musical time-weight. According to this approach, neat spatial arrangements come together with neat, measurable “ebb-flow” units (tacti) of aesthetic/expressive time, represented in the most basic form as periodic regular successions of hierarchical down- and up-beats. But whereas this is fully functional if there is an acceptance of a fundamental unity of purpose and integration of body motor, expressive and contingent time patterns, it is no longer justified if this principle is not accepted. Outcomes in music notations from the early twentieth century onwards bear witness of this reluctant, or non-, acceptance in their continuous searching for freedoms that go well beyond the highly sophisticated nuances of musical time management of previous centuries.

The situation is ambivalent, however, because the great majority of the music that has challenged and rejected this tacit aesthetic approach is still nearly all written using a completely traditional metre-based notation. In this case, metre simply means quantification of time, and bars are used for visual arrangement of sequential and simultaneous events. This continued adoption often comes with explicit or implicit warnings that down- and upbeats do not mean much (as with the 4/4 time-signature used by composers such as Ligeti or Donatoni), or within music that deliberately seems to deny the hierarchical valence of downbeats (or any beat) by hiding them within confounding surface rhythms (e.g. tying them over from before). Occasionally, metrically-written downbeat-denying musical passages paradoxically use time-signature changes, inevitably giving the impression that these quantitatively suppressed beats might still have a qualitative musical time-weight after all, possibly at an irregular hypermetric level. An example of this can be found at the beginning of *Density 21.5* for solo flute by Varèse, where in the first eight bars there are only two clearly articulated downbeats (Fig.28a), the very first note of the piece and at the beginning of bar eight itself that is however not invested with a particularly important rhythmic or melodic hierarchical moment (Fig.28). Of the three time-signature changes of the piece, the first (bar 28, into 5/4) seems to be motivated by a written-out ritardando and a rarefaction of the musical gestures, and the other two immediately following it (bars 29, 3/4 and 30 back to 4/4) clearly connect the expressive weight of hierarchically placed downbeats with important musical gestures (Fig.28b).

Fig.28a, the beginning of *Density 21.5* for solo flute by Varèse; ©1946 by courtesy of Casa Ricordi.

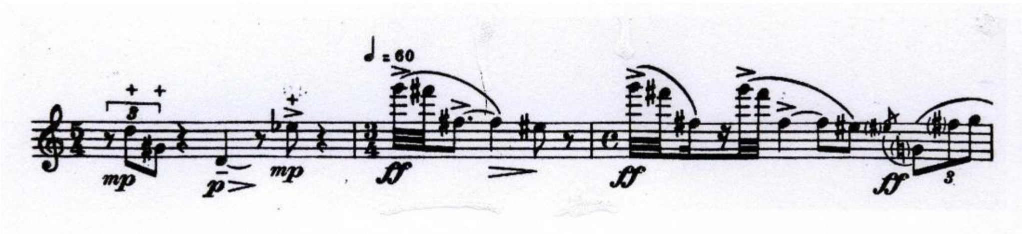

Fig.28b, bars 28-30 of *Density 21.5*; ©1946 by courtesy of Casa Ricordi.

This dissociation in substance of rhythm and metre, and the use of bars simply as a pragmatic notational tool, is fully established in art-music as a compositional option within the first half of the twentieth century. Three influential testimonies are significant in relation to this development.

In the first, Schönberg (*The Musical Idea,* 2006/1934: 146-149) affirms that rhythms should behave like motives, basically possessing an "enduring Gestalt" that can be varied and transformed in the same ways as melodic themes can be. In listing types of rhythm classification, he describes a range of relationships that they can have with the bar in which they are notated, including very loose and non-rational ones. It is clear therefore that an enduring rhythmic Gestalt does not necessarily need to fit with the pre-set hierarchical metric structure of the time-signature employed. Rhythms, however, in order to have a Gestalt at all, and one that is "enduring", in others words that can be varied but remain recognisable, need to have a compositional structural order and a set of identity-bearing elements. Therefore a notion of metre emerging in experience must apply to them even if it is not the one used in practice to notate them. This of course raises the question of how time-signatures for such rhythms are chosen in the first place, and if indeed these choices still imply a meaningful relationship of rhythm-Gestalten with the ebb-flow structure of traditional metre.

In the second, Messiaen (*The technique of my musical language*, 1944) describes “ametrical” music where the notion of measure and beat is replaced with “the feeling of a short value and its free multiplications”. This approach is initially inspired by Gregorian chant and Indian music and developed conceptually and practically into “rhythms with added values” and “nonretrogradable rhythms”, that can be then transformed following the normal procedure of augmentation, diminution, retro-gradation, and that can be treated texturally as polyrhythms and canons. He also explicitly challenges traditional notational systems and says that these rhythms should not be written using time-signatures, and bar-lines should be used solely for marking musical phrases and other similar structural events. Even though in practice he finds other half-way solutions more performance-friendly, he shows remarkable consistency between concept and practice. Interestingly Messiaen, faithful to his own aesthetic approach that “the melody is the point of departure” of music (Messiaen, 1944: 8), nearly always gives examples of rhythms embedded in their melodic and harmonic shapes, and explicitly talks of appoggiatura, of accents, of “up-beat-accent-termination”, and of adding or subtracting small durational values to create acceleration and retardation in relation to upwards and downwards melodic motions. It seems therefore that, at the same time as dissociating himself from the metrical notation at bar level, he points towards the existence of structure and order in rhythm, therefore to a proper Gestalt that is in turn both a condition of a rhythm’s enduring identity through compositional transformations and, more fundamentally, the foundation of its intimate links to the much greater musical context of melody and harmony. The music might be ametrical in relation to its notation in practice, but there is metre in it in substance, clearly connecting the ebb-flow of basic metric structure to that of its melodic counterpart. The ebb-flow description of metre seems particularly appropriate here, because it is linked to upwards/downwards melodic movements; an appoggiatura as a rhythmic and melodic event loses all its meaning outside a metrical context, however notated.

In the third, Carter (article for *Music Journal*, 1965; in Stone, 1977: 244-247) writes of how, through contact with the music of Schönberg, Ives and Ruggles, he started to work more systematically on rhythmic procedures. The result was the compositional use of stratified rhythms (*Sonata for Cello and Piano*), of metric modulations and patterns of "measured retard" and accelerando (*First String Quartet*), and of stratification of the "repertoire" of musical gestures, intervals and rhythms (*Second String Quartet*). Here a full range is given of highly structured and ordered patterns in duration and in speed, individually or layered, whose specific identities need to have a certain level of independence from the general notated metre. Of these procedures, metric-modulation has a particular importance (see also Schiff, 1998: 41-43). Although essentially a rhythmic coordination device, it works musically only if these rhythms are measurable, structurable, and reproducible within their shifting musical surroundings; essentially if they have an enduring Gestalt. He goes further and, on his *Double Concerto for Piano and Harpsichord*, says that "means of metric stratifications can be used in various ways to express different affects in the course of a work", making explicit reference to an order in duration that is functional to the wider expressive musical context.

In the discussion of these extracts I have used two concepts. One is Schönberg's "enduring Gestalt" as a quality that all the three examples, directly or indirectly, seem to find essential for rhythm. It includes three important elements. First of all, *Gestalt* means "configuration" (see Keller, 1951: 401), a specific design, an order in the presentation of constituent elements. Secondly, because it is a term coming from the psychology of perception (see Gross, 2005: 244), it refers to the unified apprehension of this configuration, an identity-giving cognitive act in listening. Thirdly, "enduring" means that, whatever happens through transformations and variations, this configuration will not lose its identity but it will always be, to a sufficient degree, recognisable. Therefore, to talk about "enduring Gestalt" of rhythm means conceiving sequences of durations that not only have compositionally well defined, finite and reproducible and transformable structures, but that can also be cognitively apprehended, followed, remembered, recognised and predicted in the course of a piece. Both aspects imply the presence of metre in substance.

The other concept is what I referred to as the ebb-flow periodical structure of metre, founded on the unified but subdivided nature of the tactus (1:1 and 2:1; see 4.3) that, as previously discussed, is supported by both music theory/pedagogy and music psychology; a pattern of continuous alternation of tension and relaxation that is intimately bound to musical practices (composition and performance) and to aesthetic and expressive approaches. Of the three examples, Schönberg seems implicitly to subscribe to it as a compositional option, but both Messiaen, through the connection between rhythm and melody, and Carter, through the connection between rhythm and expression, support it explicitly as existing alongside (and enabling) the enduring Gestalt of rhythm.

Even if, however, a general ebb-flow metric Gestalt is accepted, a problem seems to arise when it recurs at regular intervals, forcing the same uniform repetitiveness upon units of musical gestures, and moreover when this is pervasive across the whole hierarchical spectrum of rhythm notation. This regularity does not fit always with the musical aesthetics of the twentieth century, hence the experimentation with compositional resources that break it (e.g. Schönberg's non-rational relationship between rhythms and bars). As alluded to earlier, these include among many others 'irrational' tuplets, changing time-signatures, avoidance of musical accents on the main beats or avoiding time signatures altogether. This process is aimed at a greater freedom in notation in order to pursue, from the micro-level of subdivisions to the hypermetre of grouping, a greater range of possibilities in the organisation of musical durations. Duration is a key word here, and the whole aesthetics of musical time of the twentieth century cannot be entirely dissociated from the emergence of a philosophy of time, of a phenomenological nature, that early in the century, particularly with the French philosopher Bergson, was drawing attention to the fundamental incompatibility between measuring spatialised time and experiencing durational time (Bergson, 2002: 4-5; see also Campbell, 2010: 228-230; London, 2002: 717 and Hasty, 1997: 299-301). An example of the first is the time of the clock, translatable in music as, for instance, a regular time-signature-driven rhythm. An example of the second is time as experienced in consciousness that in music would be the search for more flexible ebb-flow patterns of rhythm.

Some music seems nevertheless to have rejected the ebb-flow principle itself, however freely pursued. A hint of this is already present in Messaien's mention of additive rhythms, constituted by short values and their free multiplications added together in sequences. In putting the smallest unit in charge, this additive approach explicitly moves away from the rhythmic middle-level that, even in the case of notated irrational-metres, is fundamentally still ebb-flow based. The result is more fundamentally ametrical because these numerical operations do not obey any metrical or hypermetrical design, though in some cases they might resemble it, particularly in structures of rhythmic patterns at local level that could be said sometimes to possess a kind of micro-metric Gestalt.

An extreme case of this rejection is the concept of isomorphism between pitch and rhythm, explored in practice and theory by some composers and musicologists, whereby numerical concepts and values taken from pitch are applied to durations, not as a practical notational arrangement, but as possessing equivalent ontologies. In some cases the deep influence of the dodecaphonic technique is strongly felt. Examples in composition include durational values based on the numerical properties of the 12-equal-semitone pitch-space (i.e. Boulez; see Koblyakov 1990: 35, 37) and rhythmic organisation based on concepts of pitch-class set theory whereby, from 12 pitch-set classes, 12 duration relationships are derived (Babbitt, 1962: 52-53), or time-point classes (Rahn, 1975), and are fully adopted as compositional device (Morris, 1987: 299-312). In some others, it is the full spectrum of frequencies in a physical sense in its relation to the ear's perception capabilities, as in Stockhausen's pitch-rhythm continuum and rhythmic durations as harmonic series (in London, 2002: 717-718).

If these rhythmic compositional and theoretical positions are, however tangentially, inspired by the philosophy of time touched upon earlier, the attempt to portray ever more nuanced patterns of psychological durational time seems to be pursued by an extreme form of spatialisation of time itself in notation. The same applies to conceptions of rhythm that are based on isomorphism with pitch, whether in terms of discrete values (Boulez's striated time) and often based on 'modulo 12' operations, or in terms of a frequency spectrum (Boulez's smooth time, see Campbell, 2010: 233) based on the physically continuous nature of durational patterns, and pursued more effectively in the electronic medium than in the acoustic one.

The compositional ambivalence towards metre has pervaded musicology too, as can be seen by the following two contrasting examples. Forte approaches the analysis of rhythm in early twentieth century music with an essentially additive durational procedure. He looks at a deliberately wide cross-section of composers (from Schönberg, Webern and Stravinsky to Debussy, Scriabin and Bartók) to illustrate that "rhythm in non-tonal music of the early twentieth century is intricately associated with pitch events" (Forte, 1983: 26); and more specifically that in Webern's music, in general, pitch-class-set structures are intimately allied to fundamental rhythmic structures (Forte, 1980: 109). In all these cases there is no significant reference to metre. However, Hyde maintains that Schönberg's 12-note music still displays metrical concerns in setting up, at the beginning of pieces, of movements or of sections, metrical structures or gestures that provide both material and expectations upon which the music develops (Hyde, 1984: 49-50).

The degree to which the complex numerical tools broadly used in composition and in analysis fit with, or resemble, the way we experience rhythm is debatable. It has not been challenged by composers or analysts, but the impression is that there is a rather idealistic or naïve, or perhaps unreflectively introspective, approach to it, with a considerable blurring of boundaries between what can be asked of perception in terms of grasping what is going on, and how far intellectual schemata can push the complexity of it. In this respect, a more general issue emerges in relation to the extreme spatialisation of notation and to an isomorphic approach to space-rhythm, which is what the relationship of visual and aural perception can be, and if there is any equivalence in the way they reciprocally operate.

That the listener's perspective is, sometimes explicitly, relevant in composition is clear from the following words of Carter, from the same article mentioned earlier:

> A work that does not take into account the listener's ability to distinguish sounds, to grasp, remember, and compare in some way their combinations, both sequential and simultaneous, in small durations, intermediate lengths, as well as over the whole composition, is very unlikely to hold a permanent interest for the listener. (in Stone, 1977: 244)

While no-one would deny the soundness of this statement, which includes all the main operations of cognition and connects them to the more global domain of interest (including the aesthetic one), few also would deny that the way in which this is pursued by Carter himself, and other composers that would subscribe to it, is not at all straight forward.

Clarke, from a position that tries to mediate between the listening and composing perspectives, is particularly clear both in highlighting the importance, for listeners, of being able to grasp hierarchical or associative elements in music in duration, and in summarising the uncertain compositional outcome of complex rhythmic organisations that have ambivalent or problematic approaches to metre, with the consequences that “impossible and unthought-out demands are made of both listeners and performers” (Clarke, 1987: 236).

The importance of metre, in fact, is not questioned by the psychology of music, which puts it firmly and unambiguously at the centre of research. What emerges is the understanding of metre as a “kind of listener behaviour” (London, 1999: 270), as a “mode of attending” (Gjerdingen, 1989) to time, based on the ability of listeners to entrain rhythmically with a piece (see also Povel and Essens, 1985; Riess-Jones, 2009: 83). This rhythmic entrainment process is seen as the “regularised ebb and flow of attention over time” (London, 1999: 270), which includes not only the active role of the listener in creating metre to guide the experience of time (attention), but also the ebb-flow structure of this active behaviour, that is tantalising very close to the ebb-flow structure of tactus of musical theory. London adds “if meter is regarded as a species of entrainment, then the rhythm-versus-meter distinction is precisely that between durational structure…versus the attending behaviour of the listener” (London, 1999: 271). In this sense, the relationship rhythm/metre acquires a greater dimension than simply a composer with his/her ideas; it opens up an important and uncompromising relation between a composer and his/her own cognitive capacities.

4.6) Morphology and syntax of *Pneuma's* rhythm-space

In the use of its rhythm-space, *Pneuma* subscribes entirely to the position that there are clear connections between the cognitive, and embodied, the aesthetic and the practical-notational aspects of musical rhythm, and that therefore there is a fundamental ebb-flow metric Gestalt to our experience of musical time. Essentially, this space embraces the idea that listeners have an active role in shaping their durational understanding of music, that this active participation is founded upon cognitive processes that are ebb-flow based and becoming gradually better understood, and that it is possible to set out a template that enables the basic rhythmic structures of a piece to harmonise with what is known of these basic cognitive operations. This space attempts therefore to be a listening template as well as a compositional one.

In order to discuss how Pneuma's rhythm-space is used in practice, further considerations needs to be given both to its morphology, that is the description of its various components, and to its syntax, that is how these components relate to one another over time. Its morphology is based on the properties discussed earlier (Fig.23b, and 4.1-4.3), and specifically on the presence of a central tactus *a*, set at the indifference interval duration, on its internal subdivisions according to the 1:1 and 2:1 ratios, and on the creation of two more tacti based on those ratios: the slower tactus *b*, 3/2 of *a*, and the faster tactus *c*, 2/3 of *a* (see Fig.22). Level *a* corresponds to the basic durational unit of the piece as notated in the score and, because it is linked to the conductor's beating, it has a stronger physical presence than the other two tacti, that are present almost in a virtual way through the durational, melodic and articulation features of the music (see 4.4.2). The space, as shown in Fig.23a, covers values from the shortest structurable duration to the longer limits of the perceptual present, within these boundaries nearly all rhythms of the piece are contained.

A further characteristic needs to be added to these, and that is the way in which the three tacti intersect with one another. As described in 4.4.3, a high level of simple synchronisation across the three tactus levels is pursued. To this end, a common starting point is given to the three tacti and a 4/4 metric structure is applied to all levels, which can be usefully seen as real or virtual according to its level of agreement with the notation of the piece (that correspond to level *a*). This generates an ebb-flow cycle whereby the three downbeats synchronise together every six notated bars, corresponding to four in the slower tactus, and nine in the faster. In addition to this, levels *a* and *b* synchronise every three notated bars, and levels *a* and *c* every two (Fig.29).

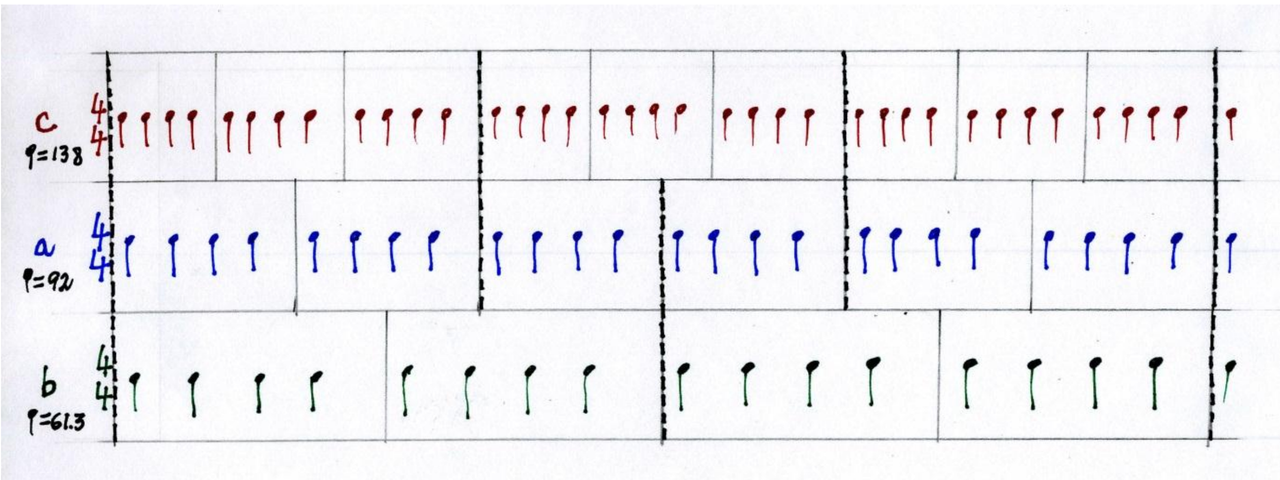

Fig.29, the 4/4 metres and the synchronisation cycle of the three levels.

The principles that guide the syntax of *Pneuma*'s rhythm-space can be summarised as follows:

i) At beat level, rhythms are congruent at all times with the relevant tactus and its multiples, as well as with its internal articulations according to the 1:1 and 2:1 (1:1:1) ratios, basically duplets (and derived quadruplets) and triples (and derived sextuplets).

ii) At bar level, rhythms are organised according to 4/4, 3/4 and 2/4 metres that, even in the case of the middle tactus level, might or might not correspond to the 4/4 time signature of the piece. In many instances, as for the tacti, these bars exist in a virtual way in relation to the actual barring of the piece. These metres are experienced through the emergence of met-

rical accents, though in some passages the local level rhythms don't afford univocal metrical groupings, and therefore their perception tends to remain at a phenomenal accent level.
iii) At hypermetre level, rhythms develop quite freely without systematic superimposed grouping structures (e.g. an 8 or 16-bar structure). However, a general guiding durational parameter is applied, broadly the 5-6sec perceptual present, corresponding to 2-3 bars at the middle tactus level (1-2 virtual bars at the slower tactus level, and 4-5 at the faster). Within this time-span, most of the rhythms reveal unequivocally their metric configurations.
iv) The principle of hierarchy applies consistently to the rhythms of the piece, both in the tonal and in the event connotations (see 2.6). In the first, the all-pervading duple and triple proportions are, both in subdivision and in grouping within and across the three tacti, based fully and systematically on the downbeat-upbeat/ebb-flow metre Gestalt that corresponds to the ebb-flow time-weight expressive Gestalt. All structural rhythms in the piece follow this approach. In the second, in addition to the presence of explicit metres in each separate tactus level, particular attention is given to maintaining the degree of synchronicity across the three levels, with their downbeats coinciding throughout at regular duration-spans, as described above (Fig.29). Structurally, though in practice they often remain hidden, these duration-spans are present throughout nearly the whole the piece. Syncopations and other rhythmical devices (e.g. dotted and double dotted rhythms) are mostly used to reinforce local grouping design. The only genuinely additive moments are to do with intensification or relaxation patterns, as continuous multiplications (or divisions) of the durational values, down in places to the smallest structurable unit.
v) Irregular tuplets (as already discussed in 4.4.3, Fig.27) are used locally to emphasise certain colouristic aspect of the music, always referable up hierarchically to the nearest hyper-level.

To illustrate how both the morphology and the syntax of the space have guided the actual composition process, two examples are given. The first is the initial sketch of the first section of the piece, which has only a basic rhythmic outline, basic indications of pitch in both melody and harmony, and brief indications of colour and character (Fig.30). In a minimal way, this example shows clearly the four sub-sections characterised rhythmically by differences in speed of figuration, by the layering of these different speeds and, importantly, by the presence of the three tacti (indicated as metronome marks: 60, 90, 60 and 135).

Fig.30, the sketch of the first section of *Pneuma*.

This sketch was developed by applying the rhythmic-space illustrated in Fig.23b for the creation of a fully formed rhythm, and the metric structure in Fig.29 for the coordination across the three tacti of important structural points.

The final result is given in Fig.31, where the same section (bars 1-34) is reproduced fully barred, albeit in a reduced format that includes only the musical elements that carry its main rhythmic and metric organisation. The rhythmic material is now grouped visually into the three tactus levels, each shown using a combination of the normal stave-notation following the time-signature of the piece and, above it, a one-line rhythmic summary rendition according to the relevant tactus and the emerging real/virtual metres. Circled notes carry the main metrical accents according to the hierarchical groupings of phenomenal accents determined by the overall musical organisation of the phrases, or by the articulation and slurring of the musical patterns; they are the downbeats of the real/virtual bars. Dotted circles indicate where these metrical accents would be, but without the presence of an actual musical accent. Bracketed time-signatures indicate metrical groupings that arise from the music but that do not correspond to the piece 4/4 time signature (virtual bars); un-bracketed time-signatures indicate where metrical groupings coincide with the piece's bar/metric structure (real bars).

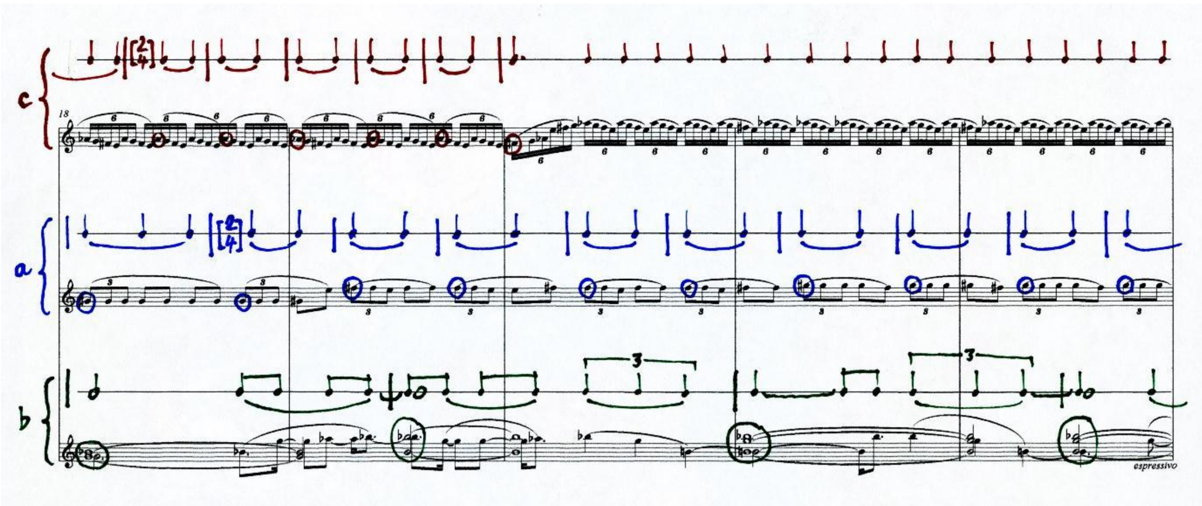

Fig.31, the first section of *Pneuma*, reduced to those musical elements that mainly contribute to its rhythmic organisation.

It is worth looking at this second example more in detail. Starting from the beginning of the extract, the music of level *b* establishes a virtual 4/4 meter throughout until this tactus level disappears altogether from this section, at bar 28. The music of level *a*, introduced in bar 11, establishes initially a 3/4 meter, virtual in its down/upbeat placements but whose tactus, as discussed before, coincides physically with the piece's central durational value and barring pattern. From bar 15, this meter continues supported by the slurring of the musical patterns, and it subsequently follows their changes (bars18 and 26). In bar 27, it ends up fully adhering to the piece's notated time-signature (4/4). The music of level *c*, from bar 15, initially establishes briefly a number of virtual meters (2/4, 4/4 and 3/4) that change according to the changing slurring of the musical pattern (bars 15-19). From bar 20, any grouping of these patterns beyond the local repetitive slurred quadruplets becomes unclear, and the establishment of metre is thus not possible; the whole passage seems more of an additive rather than hierarchical nature. In fact, there is a quick gradual shortening of slurred groupings until each single note is articulated separately (*sciolte*), with each separate semiquaver of the sextuplets (bar 27) being at the shortest durational end (108ms) of the temporal envelope, on the edge of structural comprehension. It is only in bar 27 that a clear meter emerges again (virtual 4/4) and continues to the end of the extract.

From this brief analysis of each separate tactus level, it is clear how points i) and ii) discussed above (organisation of beats and bars) apply in practice to the piece, including the hierarchical/additive issue mentioned at point iv) (bars 18-26 of level *c*). Regarding point iii) (presence of hypermetres), even though there is no evidence of recurring regular bar-length phrases, the perceptual present time-span creates a durational envelop within which all melodic/metrical gestures have a clear stability. Essentially, tonal and event hierarchies inform the whole rhythmic organisation of this extract in each of the three tactus levels.

More complex is the issue of these hierarchies across the three levels. Although the morphology of the space is set up according to the specific synchronic cycle described above (six notated bars), in practice each tactus level is not confined to a real/virtual 4/4 bar structure; in the extract presented, in fact, very little follows that metre systematically. The result is that the greater variety of metres brings a greater fluidity to the relationship of their real/virtual downbeats. Nonetheless, they do coincide in two important moments. The first is in bar 15 (figure A), where a clear change in the musical material in level *a* corresponds to the beginning of new material both in levels *b* and *c*. The second happens on the downbeat of bar 27, where level *b* comes to a close and levels *a* and *c* start with new ideas. The distance between these two points corresponds to two six-bar cycles, thus falling under the original structural morphology of the space, but the musical phrases in between do not follow this design.

To evaluate other significant moments of downbeat coordination, tactus levels need to be looked at in pairs; two further occurrences are interesting in this respect. One is at bar 12, where the expected downbeat in level *b* turns out to be and is instead marked by a real down/beat in level *a* (albeit following a virtual 3/4 meter); it is as if the first virtual bar of level *a* had an up-beat hypermetrical function. The other is the whole passage from bar 27 to the end, where level *a* follows a real 4/4 meter and level *c* a virtual 4/4/ meter, thus neatly coordinating their ebb-flow patterns according to the original structural morphology.

In many ways the relationship between Fig.30 and Fig.31 is straight forward. The translation from unbarred outline sketch into the fully developed, barred and structured final version using the rhythm-space is quite unproblematic (see for instance the similar broad differentiation of musical speeds, the three different tacti, which remains the same, and the structural, synchronic downbeats at A and at bar 27 that correspond to the sections in the sketch called “acido” and “genesi” at the end of the first system and the beginning of the second, indications that were incorporated into the orchestration and thus disappeared from the score). However, this translation could have taken very different directions at local level, and in fact it has stretched the space in many ways, particularly the downbeat grid of Fig.29. As in all practical compositional situations, the relationship between concrete details and a guiding musical space is one of continuous negotiation. The advantage of adopting a template that is developed upon cognitive foundations is that, in addition to the somehow guaranteed communicability of the musical elements, the degree of compliance or variation with the template itself becomes transparent and therefore structurally meaningful.

5) Common concerns

Having developed a pitch-space and a rhythm-space independently, according to their own principles, each combining general principles of foundational music theory/pedagogy and *ad hoc* principles of theory/analysis and of cognitive psychology, there are common features that now need to be considered.

5.1) Redundancy

Both spaces are, to use process-based information theory, redundant (see Shannon and Weaver in Fiske, 1990 and Cohen, 2005: 66). In communication theory, the communicative power depends in general on the capacity of its transmission/reception channel, and the accuracy depends on how content fills the channel itself. According to this approach, redundancy means that a message contains a significant amount of repetition and conventionality, thus relatively less information and a high level of predictability. Entropy on the contrary means that a message contains minimum repetition, thus more information and low level predictability. The first type allows for a margin of noise that, Fiske says, is “anything that makes the intended signal harder to decode” (Fiske, 1990: 8) and that can be divided into semantic (involving the coding/decoding of the signal) or engineering noise (involving the means of transmission). There is enough repetition in a redundant message for the content to arrive safely, and in this sense “redundancy is not merely useful in communication, it is absolutely vital” (Fiske, 1990: 10). The second type does not allow for any noise, because this would irretrievably compromise the content of the message.

Without entering into issues of musical content as meaning and considering it, for the purpose of this discussion, exclusively as surface/structure relationships, the approach here in both musical spaces has been to aim for the former, redundant type whereby the communication channel capacity is set both by limits and modalities of perception of pitch and durations, and by their cognitive processing (e.g. memory).

In the perception of pitch, the division of the octave in 12 semitones seems to be the maximum structural channel capacity for practical music making, despite extensive claims (many of which in theory) of micro-tuning in many art-music and traditional-music contexts (see Burns, 1999: 251, 257). It is important to stress that this limit applies to pitch in music settings that specifically require structural perception and reproduction. In those that allow or demand fine-grained expressive features, micro-tuning is absolutely vital and omnipresent; Clarke's middle and low levels in the conception and perception of durations, discussed earlier in 4.4.4, if applied to pitch can clarify this point. It is also important to stress that this 12 semitone division is not necessarily the equal tempered scale, and that its intervallic variability in other temperaments is entirely structurally transparent if considered within their overall context.

The pitch-space of 5-22 acknowledges this basic overall capacity of structuring frequencies in perception. Its level *e* corresponds to the total channel capacity. Music that dwells in it is essentially entropic in the structural experience of pitch that generates; any musical 'noise' is hard to detect as noise. The message is rich in information from the sender but extremely fragile at the receiving end. This music thus often resorts to other parameters to introduce some form or redundancy such as, for example, a well-structured repetition pattern in 12-note music, a series.

In *ed erra l'armonia*, the music itself never adopts level *e* in practice, and remains confined within level *d*. This is structurally redundant because there are four pitch classes that are not present, and the spare channel capacity is used to host repetitions of any of the remaining eight. The message is somehow less rich from the sender, but stronger at the receiving end.

In the perception of durations, taking London's temporal envelope (100ms to 5-6 seconds) as the basic capacity of the communication channel, the extent to which any rhythmic organisation can be apprehended through a repetitive pattern within the metric envelope (250ms-2-3 seconds) would determine whether the message is structurally redundant or entropic. Duration patterns that do not establish any repetition pattern, or escape these envelopes if they do, would be entropic; those that establish a pattern of repetition within both, and particularly the second, are redundant. Again, this applies to structural hearing of durations, not fine-grained expressive local fluctuations.

In the case of *Pneuma*, important aspects of the redundancy of its rhythm-space include the structural use of durations within the temporal envelope, and the structural use of most metrical aspects within the metrical envelope. In particular they include the fact (see 4.4.3) that the three layers of metre do synchronise systematically within those envelops. Of all the possible durational relationship conceivable, only that which allows maximum simultaneity between the three is used, with the result that there is a considerable overall overlapping of ebb-flow patterns, with regularly coordinated ebbs (downbeats).

In terms of cognitive processes, memory plays a fundamental role in the issue of redundancy versus entropy. Memory latches onto and profoundly influences our structural sensory capacities, and enables further processes of understanding and appreciation. Two cognitive psychology studies are particularly important in relation to this.

Snyder concentrates on how our mind imposes maximally efficient ways of processing and retaining musical information, essentially searching for patterns of regularities, predictability and hierarchical nesting that allow quick access and recognition/interpretation of signals despite memory limitations (Snyder, 2000). In relation to this, he refers broadly to two different categories of music: one that remains within memory's associative and hierarchical boundaries, the other that goes beyond it and sabotages it (Snyder, 2000: 234). The first is equivalent to a redundant model of information, whose inbuilt repetitions help the information to be rehearsed, retained, structured and built up hierarchically (from echoic, to short-term and long-term memories; Snyder, 2000: 6). The second is equivalent to the entropic model.

While Snyder's focus is on the emerging of structural experiences of music (understanding), Huron is concerned with their emotional valence through patterns of expectation and fulfilment (Huron, 2006); the two are entirely compatible, as Huron's ITPRA theory relies on processes of learning and of creating and recognising cognitive schemata that are heavily dependent on memory. According to this theory, whose acronym stands for Imagination-Tension-Prediction-Reaction-Appraisal responses, the building up of expectations and the experience of fulfilment play a crucial role in the activation of musical pleasure that he specifically attaches to reward for accurate predictions. If music is to generate a pleasure response, it must allow for its own unfolding to be predicted through the use of conventions and repetition (Huron, 2006: 367). Here again therefore, redundant rather than entropic information seems to match this process better, as it carries both conventions and repetitions with the specific purpose of keeping the message both clear to circumvent 'noise', and sufficiently predictable to generate expectation and fulfilment patterns (see Huron, 2006: 140). The compositional challenge is therefore to channel what is novel and complex in the (structural) content of communication in such a way as to generate the interest of the receiver. Novelty and complexity contribute to music's pleasing-ness, but only up to a certain point, after which, possibly when entering the entropic domain, it quickly produces the opposite outcome (Cohen 2005: 73).

5.2) Hierarchy

A common feature of the two spaces is also their hierarchical organisation, the nature of which in relation to music in general has already been discussed (see 2.6).

The pitch space, conceived visually as a vertical pyramidal structure, is devised so that there is an inbuilt attraction towards a central pitch, generated by formal properties of the space itself and where any musical object/motion tends to find a point of rest at the centre, high up in the structure. There is a convention by which, generally, hierarchies move upwards in the ranking of its members; in music a reverse image would be more appropriate, as fundamental pitches at structural level are generally connected to lower notes and slower rhythmic/metrical motion, a force-field approach that follows the attraction and gravitational analogy sometimes adopted in music (see Lerdahl, 2001: 166-7, 170 for its use in relation to melody). In the following visual representation (Fig.32), the pyramid is applied to the hierarchical positioning of 5-22 within 8-27, and it is vertically inverted to allow for the cascading gravitational analogy not dissimilarly to Krumhansl's approach to the representation of a tonal space, where the tonic is at the vertex at the bottom of an inverted cone (Krumhansl, 1990: 128).

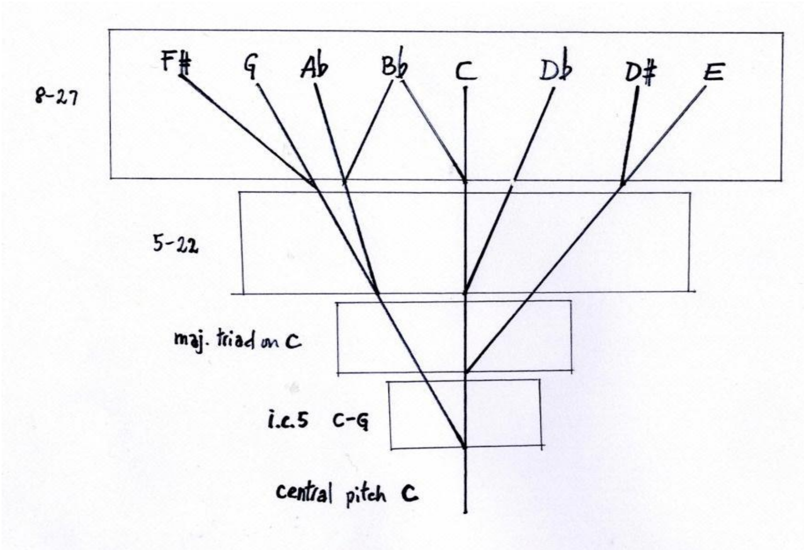

Fig.32 , a representation of the pitch hierarchy of 8-27 and 5-22 (based on C) according to the gravitational analogy, that essentially reverses the direction of the pitch space presented in figure 8 with the important difference that, this time, C is given unchallenged hierarchical position following compositional choices made for the piece *ed erra l'armonia*. The lines represent voice leading resolutions cascading downwards towards more stable pitches.

The rhythm-space is a durational structure that has a centre in the regular repetitions of the ebb moments of the ebb-flow of metre (discussed in 4.2). As it has been discussed, in *Pneuma* there are three layers of metre and therefore three musical ebbs (downbeats), one of which happens to correspond, most of the time, to the bar-structure of the score (with crotchet equal 92 bpm). The moment that simultaneously combines the three layers is the one that is hierarchically most prominent. This hierarchical space is horizontal rather than vertical and, rather than a force-field, it visually represents the pattern of the experience of time for which a phenomenological approach is adopted (see Ihde, 2007: 85-102). According to this, the perceptual present moves from the predictive experiential edge of the future (not dissimilarly to the projective generation of metre, see Hasty 1997) to the fading-away retention of the past (which triggers the cognitive mechanisms of memory, see Snyder, 2000); an experience that could be equated to predicting-watching-remembering a landscape through which one moves sitting on a train backwards to its direction. The following visual representation (Fig.33, based on Fig.29), where time moves from left to right, is a horizontal pyramid that shows in the central area the perceptual present, on the left the predictive efforts towards the future and on the right the passing of time and retention of the past. The experience of time is here visually captured at the hierarchically most prominent situation when the ebb moments (downbeats) of the three tactus layers coincide. The more the experience moves towards the left, the more only the most important structural element in cognition are retained (on the right) and possibly hierarchically organised.

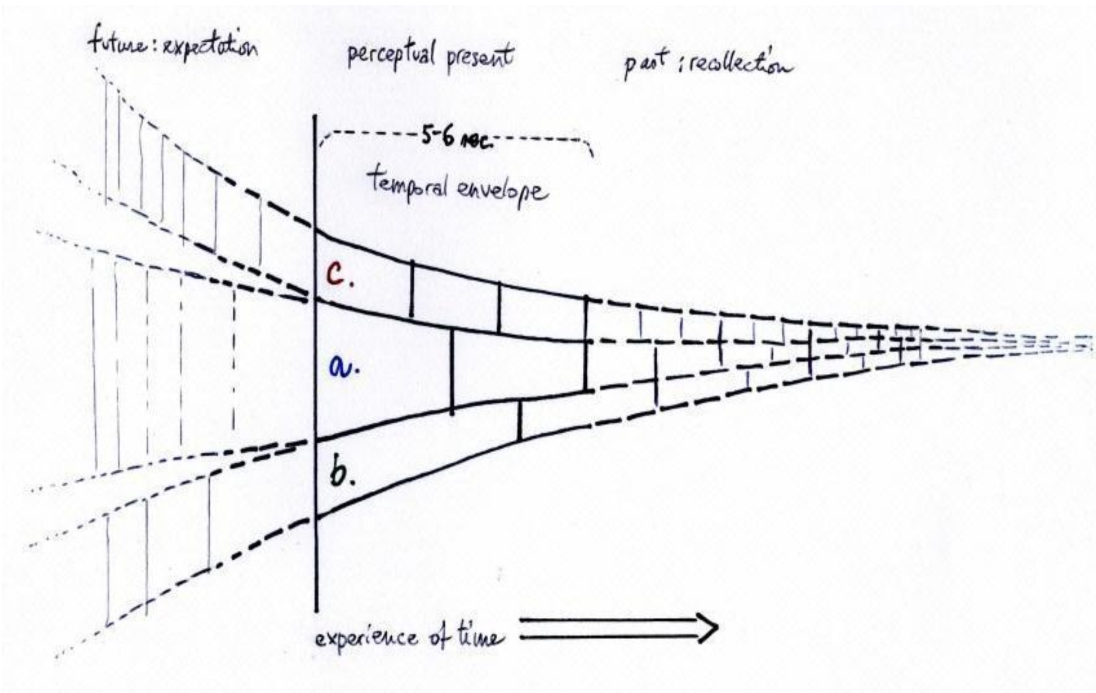

Fig.33, a possible representation of the experience of time and the hierarchy of *Pneuma*'s rhythm-space. The main vertical line is the edge of the present, and the temporal-envelope represents the perceptual present of Fig.23; *a*, *b* and *c* are the three tacti arranged as 4/4 bars. The experience is captured here when the three tacti are reciprocally synchronised.

5.3) Beyond hierarchy

The compositional use of both spaces should therefore allow for the pursuit a musical content that is redundant, that is memory compliant and ultimately cognitively transparent. However, within the same spaces, musical material can be used to aim for the opposite of these set-ups: for entropic content, for memory-sabotage and for cognitive opaqueness (as used in Lerdahl, 1992: 98; see also 3.3). How far this could go would ultimately be limited by the intrinsic properties of the spaces, but it would offer valid alternatives to cognitive hierarchies and compositional centredness, in pursuit of a wider range of artistic designs (e.g. patterns of tension and release, of continuity and contrasts). Moreover, even though the opposite outcomes of cognitive transparency (e.g. through hierarchy and redundancy) and opaqueness (e.g. though entropy) are mutually exclusive, they can usefully be conceived to lie at the extreme ends of an experiential continuum that includes the intermediate steps of salience and association.

Lerdahl discusses salience as a psychoacoustic parameter that can be understood as a gradual substitute to structural stability in the perception of heavily chromatic and atonal music (Lerdahl, 2001: 313, 349). Salience consists in the grabbing of our perceptual focus by specific musical elements within a flux of events. It is basically a locus of attention (Lerdahl, 2001: 315) that shapes our real-time perception, a “less structured and more continuous form of mental processing” (Lerdahl, 2001: 381) whereby musically notable events stand out cognitively without becoming structurally connected.

With association is meant cognitively connecting musical elements by contiguity and similarity (to apply Meyer’s parameters of meaning to the relationship of surface and structure; Meyer, 1956: 260-262) without working out fully structural hierarchical relationships. It is based on salience but it necessitates a higher level of overview.

It is conceivable that these four stages (opaqueness, salience, association and hierarchy) could be seen therefore not just as mutually exclusive experiences, but also as progressive steps of perception and understanding. In this sense, there would be an experiential evolution from one to the other as, for instance, a listener becomes more familiar with a particular style and piece; as he/she rehearses more and more a specific listening experience, from initial opaqueness salient events would be singled out and gradually connected in an associational manner, and even possibly hierarchically.

Whether this pattern could also be replicated in composition is debateable, because generally music material tends to be developed according to choices that are not, at least not consciously, opaque but fully associational if not even fully structurally unified (hierarchical). However, this might be true more to a composition nearing its final stages. Lehman et al. (2007) present a compositional model made up of various phases: preparation, incubation, illumination, elaboration and verification and, within these, the experiential evolution described earlier might be conceivable if applied to the elaboration phase “during which trial-and-error work becomes important…until an acceptable solution has been found” (Lehman, Sloboda, Woody, 2007: 133). Finding a solution means understanding the problem; this can be translated compositionally into sketching initial ideas and gradually, through a period of trial-and-error, understanding their potential as to how they can grow in to a piece.

Music works by using many different parameters simultaneously. Snyder divides them into primary and secondary: the primary parameters include pitch, harmony and rhythm, essentially all the elements that “can have relatively fixed proportional relationships between them” (Snyder, 2000: 195). The secondary parameters, that include for example articulation, timbre, loudness and others, are elements that “operate in a ‘more of’ or ‘less of’ way” (Snyder, 2000: 199). Even though he states that there should be no definite priority between the two sets, invariably Western music theory/pedagogy, theory/analysis and cognitive templates have tended to concentrate on the primary parameters, and the approach here, by concentrating on pitch and rhythm, has conformed to this too. However, once all musical parameters are present together, the scope for the application of the opaqueness-salience-association-hierarchy continuum in composition increases considerably, because different parameters can be placed simultaneously at different stages on this continuum itself. The increase is in fact exponential, as the overall combination comes into play in addition to the single ones. The following examples taken from *Pneuma* and *ed erra l’armonia* illustrate the use of entropy and redundancy in pitch and rhythm, simultaneously at the opposite ends of the experiential spectrum.

Fig.34, example of entropic information in metre in *Pneuma* (bars 302-305).The three tactus levels are present through the various rhythmic designs; harmonic and melodic patterns are redundant through the use doublings in both the vertical and the horizontal combinations.

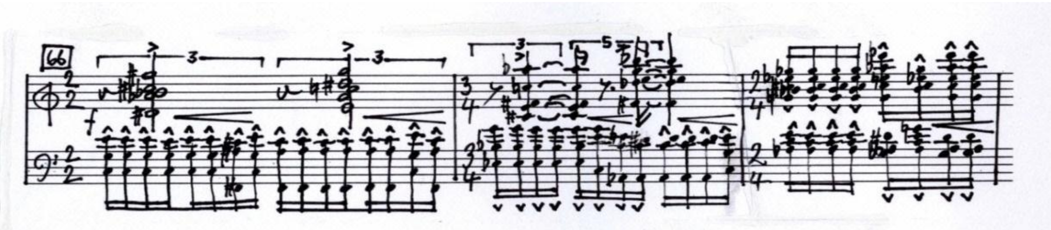

Fig.35, example of entropic pitch information in *ed erra l'armonia* (bars 66-68); 8-27 is complete; chord textural arrangement and rhythm are redundant, particularly in the triadic lower part.

5.4 Permutation and elaboration

In addition to the common issues on the morphology of the spaces discussed above, syntactical factors further contribute both to the redundancy/entropy balance in communication, and to the placement on the opaque-salient-associational-hierarchical scale, whether these are intended as absolute values or lying on an experiential continuum. Some important features of syntax have already been discussed for each of the two spaces, but it is worth considering a more general, unifying aspect common to both.

Lerdahl distinguishes between a permutational and an elaborational way of unfolding musical phrases (Lerdahl, 2001: 375-378). In the first case, the main musical processes are based on rearranging musical elements and patterns within the possible reciprocal combinations among their members. In this way, all resulting patterns become structurally rather equivalent and need to be re-evaluated with each different change; this tends to prejudice any attempt to perceive among them a sense of structural priority or direction, beyond the musical merits of the local shapes. In the second, priority is given to the addition of further elements to the original pattern, with the structure growing in scope without losing its original bearings. Rather than starting the process of structural understanding anew at every permutation, with elaboration the understanding is cumulative, the original structure never entirely disappearing from compositional or listening "sight"; structural understanding is both strengthened by those recurring musical elements and enriched by the new features.

Psychological studies prefer elaboration to permutation as a model for human cognitive processes (Lerdahl, 2001: 378) and therefore it can be considered as broadly supporting both redundancy in communication, and the hierarchical end of the opaqueness-hierarchy continuum. Interestingly, and perhaps not surprising in practical terms, the relationship between permutation and elaboration in *ed erra l'armonia* is more complex than following exclusively either of the two approaches. There are clear elaborational features in the use of its pitch-space, such as the systematic return of the harmonic closure on pc set 5-22 (see Fig.14) and the progression of harmonies built on common pitches/pitch combinations (see Fig.12, 13a), and on common textures (such as the four-note seventh chords, the three-note triads, the major/minor seventh intervals; see Fig. 15, 16 and 13b). However, in the use of pc set 8-27, the lack of a clear motivic structure across these elaborations (unless considered at the larger overall formal context of the piece) points toward a permutational use of the space, and the reordering of the eight harmonies following the same elaborations is essentially permutational, there is no *a priori* structural order among them that is maintained throughout. In *Pneuma*, the elaborational basis of rhythm is more all-pervading given the highly metrical organisation of the piece, the clear ebb-flow repetitive structures at both individual tactus levels and across them (see Fig.29), and the systematic application of 1:1 and 2:1 durational ratios to all rhythms (see Fig.23a). Permutation can only be found across the three levels in relation to the combination of changing real/virtual metres (see Fig.31), though these individually, even in the additive mode, are clearly elaborational.

6) Conclusion

6.1) compositional templates, music theory and cognition

Both pitch and rhythm spaces discussed in this study are essentially practical compositional templates that guide musical structures according to specific relationships. These relationships express and combine both natural cognitive processes (hierarchy) and theory-led compositional parameters (centredness). Their aim is that psychoacoustic properties of the material and its unfolding following musical properties and logic should find a common purpose. When the two feed into one another, musical structural communication has a good chance of linking composer's design and listener's perception; when not, this communication is minimal, and its content is largely locked on both sides into self-referencing loops. The templates aim at this synergy not only by guiding the development of the material, but by facilitating the very creation of it.

Referring to Lerdahl's notion of a musical grammar, that is a "limited set of rules that can generate indefinitely large sets of musical events and/or their structural description" (Lerdahl, 1992: 99), and that applies therefore to both composition (generation) and listening (description), my approach explores in a practical way particularly the connection between the theoretical elements of the compositional grammar, and the cognitive features of the listening grammar. Is so doing, it broadly subscribes to Lerdahl's second aesthetic claim that "the best music arises from an alliance of a compositional grammar with the listening grammar" (Lerdahl, 1992: 119), recognising nonetheless that this is a necessary but not a sufficient condition for the evaluative "best" to be attained. Lerdahl also makes a distinction between natural and artificial compositional grammars, whereby "a natural grammar arises spontaneously in a musical culture" and "an artificial grammar is the conscious invention of an individual or group within a culture" (Lerdahl, 1992: 100). The attempt here has been to reconcile the two, with the natural side relying on the traditional foundational templates of theory/pedagogy, and the artificial pursuing individual processes for devising musical material. This reconciliation is due in significant ways not to a pseudo-scientific deterministic match, but rather to a personal mythopoetic plan (see 2.8), and therefore it goes significantly beyond the music theory/music psychology split mentioned earlier (see 2.6): composition can, and must, find a common practical ground that goes beyond their tendency to absolutist claims.

6.2) From cognitive constraints…

Earlier (see 2.3) it was considered how, for Stravinsky and Messiaen, the application of self-imposed theoretical and numerical constraints on musical material could enhance compositional resourcefulness. This self-limiting approach is a voluntary choice, a private matter of a composer and his/her own working practices that can be ultimately evaluated only in relation to its outcomes.

It has been suggested that in music there are also constraints imposed by our cognitive processes (McAdams, 1989; Lerdahl, 1992). These are not voluntary but hard-wired in our brains, and therefore essentially unchangeable. Their acknowledgment in composition raises more objections because it can be seen as undermining creative freedom, and as limiting from the start the range of legitimate artistic experimentation. The balance is a delicate one. On the one hand, our cognitive musical capacities are compositionally still very narrowly explored, and there is limitless scope for bringing more of the less familiar corners of the musical experience into full consciousness; the kaleidoscopic nature of current musical world is testimony to this. On the other hand, there is evidence of fundamental physiological and cognitive boundaries to our perception and its organisation in time that limit the extent of that very same experience.

These constraints, essentially referring to bottom-up perception processes within the cognitive hierarchical pyramid mentioned earlier (see 2.6), can be bypassed by top-down application of schemata within the same cognitive pyramid; for instance they can be stretched by memorisation, trained by statistical learning (whereby knowledge is acquired through exposure to stable environments, see Huron, 2006: 360) and influenced by social and cultural habits. These ‘corrective’ processes, however, are not a fully satisfying answer if the compositional approach is concerned with the immediacy of the musical experience at perceptual level and the inevitable guiding impact on it of intuition, intended here, following Lerdahl and Jackendoff (1983: 3-4), as the structural understanding of a piece by an “experienced listener” who has unconscious access to a wealth of musical knowledge and, worth adding, to sophisticated of listening skills. Even within great individual differences, this intuition is ultimately dependent on fixed, hard-wired cognitive bottom-line processes whose activation is fundamentally spontaneous. Working compositionally along these immediately-activated cognitive grains brings the powerful impact of this alignment into full fruition. In particular, to open up the possibility of a clear experience of Clarke's low-level/expressive domain (Clarke, 1987: 233; see section 4.4.4, applied in this case to musical parameters in general), it is necessary to allow a precise, immediate and intuitive grasp of the middle, structural domain. And even though the effectiveness of this low-level domain is dependent on a fluid and unpredictable behaviour of musical material, if not contextualised within the middle/structural level its scope becomes largely casual, where composer's and listener's experiences might not coincide. Finally, cognition is not a passive act, but an active one: the mind looks for stability of experiences, for organisable experiential chunks, for memorable and recognisable patterns, for optimisation of cognitive efforts facing perception data (see, for instance, Snyder, 2000: 202); in this respect, cognition is to be treated not as a passive, recalcitrant recipient of communication, but as an active accomplice that cannot be entirely persuaded into collaboration unless its own rules of engagement (a sort of cognitive rhetoric) are given sufficient attention. By setting up what might be seen as heavily restricted musical templates, the approach here has been that cognitive constraints are not an unfortunate imposition on our compositional freedoms, but the guarantor of this freedom not becoming an arbitrary experience, or one hijacked by superimposed schemata. These constraints need to be seen as no less an opportunity as the theoretical and the numerical constraints mentioned earlier. The more musical communication relies on cognitively aligned, intuitive structural experiences, the more it can aim for the experience of the unstructured and the unpredictable, ultimately of those small, flexible compositional elements that constitute a major part of the experience of the expressive.

6.3) …to cognitive heuristics

There is a compelling case therefore for cognitive parameters to become integrated with music theory and analysis, and to be part of compositional practices. Cognitive scientist Donald Merlin states that "art should be regarded as a specific kind of *cognitive engineering*"; art, he says, is part of the human tendency "for the reciprocal control of attention", it "carries with it a propensity to deliberately *engineer* the experiences of others" (Merlin, 2006, 4). Composition needs to be based on competences of cognitive processes, and this need is essentially practical; these competences are ultimately to do with how material is generated and used in practice, they guide the composition process.

Interestingly, those practices based on traditional foundational templates include what could be defined as cognitive compositional heuristics, mostly experience-based rules of thumb on how to deal with, and maximise, the listening experience according to certain artistic parameters (e.g. tonal centredness, thematic connectedness and portrayal of affections) and to certain cultural practices (e.g. style, form, genre and reception contexts). The reason for this, as seen previously (see 2.5), is the practical, comprehensive, and in many ways fruitfully unsystematic way of developing these templates according to a wealth of tried-and-tested experiences from the expressive to the structural; in this sense these templates come close to Lerdahl's natural grammars. This has, however, caused composition gradually to take cognitive parameters for granted: "usually, composers use their own perceptions to infer how listeners will perceive their music, but this strategy can overestimate the perceptual faculties of listeners" (Forde Thompson, 2009**:** 213). In turn, this taking for granted has also caused cognitive parameters to be variously overlooked (or actively disregarded) within predominantly theory-led processes, creating often gaps in the communicability of music and the failing of the experiential engineering effort. This has been particularly the case with the proliferation of individual *ad hoc* templates and procedures in art-music composition (artificial grammars), the loss of a musical *koiné diàlectos*, a common musical tongue, and of unified musical technical and cultural signposts. In this context, the old experience-based heuristics need to be re-appraised and re-formulated, and current cognitive science can show a useful way forward.

Earlier (see 2.1) the role of analysis was discussed as being Janus-like, enabling the round-trip poietic journey between theory and composition: from concrete musical material to general structures (abstraction from composition to theory) and from general properties to concrete works (instantiation from theory to composition). Within this tripartite scheme a fourth element needs now to be included: cognition. Its role could be seen, conceptually, as constituting a kind of rails along which this same poietic journey acquires greater efficacy for a communicable outcome. These rails can be expressed as three interlinked principles that converge towards cognitive optimisation; essentially cognitive-inspired heuristics for the alignment of theory and cognition in composition. This three-pronged approach is contextualised by a general statement, necessary to ring-fence its legitimacy in the current 'deregulated' compositional scenario:

<u>General statement:</u> cognition needs to be concerned, in the first place, with musical structures; it is directed towards the creation, recognition, retention and manipulation of individual details and complex wholes and of their relationships at both minute local level and overarching architecture. Within this framework, expression is the fine-grained music-surface fluidity anchored to the cognitive transparency of these structures, and meaning becomes essentially their definition and description.

<u>Principle one:</u> the nature of musical structures are to be defined according to the constituent clarity and relational implications of their components. They cognitively lie along the "opaque---salient---associational---hierarchical" continuum (see 5.2) that has a music theory parallel in the continuum of "sameness---noticeable differentiations---interconnections across differentiations---directionality of interconnections" in the relationships of musical material.

<u>Principle two:</u> the communication of musical structures is to be approached according to the density of musical information and its speed of change, and to the management of its repetitions and transformations. This is dependent upon the cognitive balancing of entropy and

redundancy (see 5.1), that has a music theory parallel in the balance between saturation and parsimoniousness in the use of musical material.

Principle three: the creation of musical structures is to be based on practical compositional templates that list the available musical elements and inter-link them according to a specific architecture. In terms of morphology, the “static” properties of this architecture can be described in music theory as additive or nested (see 3.2, pg.26); in terms of syntax, the properties “in-motion” can be unfolded in music theory applying permutational or elaborational processes within this same architecture (5.4). These correspond in cognition to a number of possible dichotomies, but the most significant one is that of instability and stability, in many ways the central concern of our cognitive processes, that is filtering through shifting data in order to build a stable and “safe” environment.

Principle 3 relies heavily of the integration of theoretical properties with results of cognitive experiments, and within this stability is a major parameter. Following the remit of the current study (striated musical space in pitch and duration), the following important points emerge for the alignment cognition/theory; in pitch: a) the structural stability, among all interval classes excluding octave and unison, of ic4 and ic5 both in a melodic and in a harmonic situation; b) the structural perception threshold of ic1 and the sequential pattern of ic1 and ic2 as spontaneous building blocks of octave-based scales and modes; and c) the anchoring strength of ic1, used melodically to reach a point of greater structural stability. In rhythm: a) the temporal (100ms to 5/6 sec) and metrical (250ms to 2 sec) envelops, within which durational structures are apprehended with an increasing accuracy; b) the relationship between additive and sub-divided durations (from the JND interval, 250ms, upwards to include also longer durational values) and their internal articulations and groupings according to the 1:1 and 2:1 ratios; and c) metre as the inevitable product of the mind’s active and spontaneous searching for stable recurring patterns of durations, and for their projection into the future.

The following table elaborates these points in schematic form (Fig.36). The three principles are shown horizontally with an equivalent range of descriptors that relate to the general issue of cognitive sabotage (cognition/theory independence) and compliance (cognition/theory interdependence), where the first gravitates on the left-hand-side, and the second on the right. The dotted connecting lines indicate gradual transition. Vertically, the three principles cascade down from the global to the local issues, or build up in the opposite direction; they can also be approached individually, but are deeply interconnected and the choices made at any one level inevitably affect the others. Each principle includes both a cognitive descriptor (line above) and a theoretical one (line below), the two expressed in equivalent/parallel ways and whose language is conceptually flexible enough to be applicable to various musical parameters (primary as well as secondary). Importantly, this table is not prescriptive, but simply a map that can help the management of these parameters on artistic terms; for instance, while pitch structures are on the right, rhythmic structures could be on the left, and *vice versa*; formal and timbral organisations could be independent from both and be placed in different places altogether. Finally, this table expresses a scenario that is valid from both the compositional and the listening angles and one that, therefore, even though born out of the current compositional climate, can also apply to other periods of music.

Principle 1: **Nature of musical structures**	Opaque---Salient------------Associational----Hierarchical Same------Differentiated---Interconnected----Directional
Principle 2: **Communication of musical structures**	Entropic---Redundant Saturated--Parsimonious
Principle 3: **Creation of musical structures** a) morphology of musical space b) syntax of musical space	Unstable--Stable Additive---Nested Permutational---------------------------------Elaborational

Fig.36, representation of the three cognitive/theoretical principles applied to musical structures.

From this table it is possible to generate a further, more detailed level of practical compositional “rules” once the very specific musical experience to be engineered is formulated, both in terms of the psychoacoustic properties of the material to be used (be this a theme, a harmonic progression, a pitch aggregate or a duration pattern), the structures to be adopted (returns and development of the material, presence of an overall pitch centre, or management of meter) and, ultimately, the compositional approach to style and communication of each composer within the wider aesthetic context. The practical compositional “rules” made for *ed erra l’armonia* and *Pneuma* were driven by the interest in combining elementary material in pitch (pc set 5-22) and duration (indifference interval) with the overall experience being pursued, that of hierarchy. This immediately implied remaining on the right-hand-side of the table in all musical choices, but it also implied planning and using possible shifting towards the left-hand-side for specific artistic reasons.

6.4) Limitations and future steps

To conclude, four more observations need to be made. The first is that, within a compositional context, cognitive psychology results on music might seem on the whole limited. Despite sophisticated re-interpretations on cognitive grounds of music theory, these results broadly relate to musical elements (e.g. melodic/harmonic intervals, duration patterns) and practices (e.g. voice leading, suspensions, cadences) that are at a rather elementary level. This is artistically disappointing, but they map out nonetheless some kind of ground level cognitive engagement-rules that are important in the current fluidity of art-music language. Within this context, an un-critical engagement with these cognitive results is not sustainable. Current literature that links musicology with psychology can also be useful in devising practical ways for composition, as it has been the case with Lerdahl and London in this study.

The second is that these results seem to link fundamental cognitive processes to certain features of foundational theory/pedagogy templates. Somehow, they are not entirely new; cognitive studies have not revealed shattering as yet unknown realities that have not been somehow already part of well-established musical practices. In fact, these practices deal with significantly more complex musical issues that cognition is able to account for at present. The cognitive approach gives, however, a whole different viewpoint on some important elements of those templates, shifting their grammatical legitimacy from a cultural to a hard-wired standpoint. It also reveals composing as the engagement, albeit through ever changing contexts and practices, with the fundamental and inevitable cognitive issues of memory, of hierarchies in pitch and metre, and ultimately, though outside the scope of the present study, of musical pleasure and emotion.

The third is that music cognitive analysis needs to be set up as a proper discipline, and become a fundamental tool in composition; the table in Fig.36 can constitute a starting point. In addition, musical material needs to be analysed according to the cognitive milieu appropriate to its nature and to the compositional outcome in mind, because not all music aims at the same experience. In this way musical communication can be more effectively engineered both in the transitive sense of composer/listener, and in the reflexive one of composer with him/herself, whether to bring out particular "objective" surface-structure relationships over time, or to use this relational transparency as a means for farther "subjective" artistic reach.

Lastly, even though these results might be taken as supporting particular musical aesthetics against others, the aim of the quest is not to find a justification of certain styles based on cognitive sciences. Rather, it is to open up music resources to go beyond what, in stylistic terms and if musical language is left to its own theoretical and aesthetic devices, is a situation that is not only positively diverse, but also unhelpfully divisive. It was said earlier (2.2) how various theoretical/analytical models can support different and even incompatible stylistic outcomes in the same piece; cognition can contribute to this project. There is a unified common experiential denominator the systematic unpacking of which can greatly enhance the intrinsic potential of musical communication and give an hyper-perspective, so to speak, on the local stylistic and aesthetic camps. The relationship style/cognition is one that certainly requires more investigation, where style might be seen as the fluid over-time relationship between the individual and collective experience of music and our cognitive instruments to deal with it. Composing at these forever partially explored edges of this relationship is, arguably, where the greatest challenges and achievements in music are.

(29,236 words)

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