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Target Practice[1]

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At times it is surely necessary for a composer to reflect upon his method. But should he express these reflections? Speaking about oneself carries risks: limiting one's development, self-censorship. For that matter, is it really up to the composer to construct his own theories? Does that not imply a failure of our musicology? If the act of observation disturbs the observed object, what do we say when the observed and the observer amount to the same thing? And let us not forget that the ambiguity of our vocabulary will not make anything easier. I do not believe music expresses meaning; therefore, terms like 'language', 'writing', 'message', 'structure', etc. can only be used as oblique analogies to spoken language. I shall always understand these words in the most general and banal sense, not as referring to some type of ideology or analytic system. To make one more point about vocabulary: they always call the music we make 'spectral'. Neither Gérard Grisey nor myself are responsible for that designation, which always struck us as insufficient. But I shall nevertheless continue to use it, for efficiency's sake, reminding myself all the while that other epithets—'serial', 'impressionist', 'neoclassical', etc.—are equally reductive.

Reading recently some reflections on Eastern (Sino-Japanese to be precise) thought, it occurred to me that, to some extent, they illustrated my attitude towards the phenomenon of music. For example, the eastern approach to defining an object might consist of successive circumscriptions of an object, rather than breaking the object down into its constituent parts. From this eastern view comes a language based on blocks of meaning, on superimposed impressions (if, indeed, the very notion of causality is not overturned); a language distinct from analytic ones like the Indo-European tongues. It is a question of 'com-prehending' (*com-prendre*) the object, in the etymological sense, to the point of identifying with it; the archer does not aim for the target: 'the archer and the target are two extremes of a single process' (Maréchal, 1989, p. 53). The artist shares this unified vision of the world; he does not try to describe an object, but tries to reflect the sense created by its impregnation in the world; 'he lives the experience of the target receiving the arrow'. It seems to me that, similarly, my material is not a musical note, nor even a sound, but the *sensation* (*sentiment*)[2] created by that note or sound. The material is not, for example, the harmonic spectrum (an object), but the harmonicity of that spectrum (a sense) and, further, the possibilities of transformation that it contains (the flight of the arrow). If

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the material is transformation, then the material is also form; the two notions unite. The musical object finds itself gradually circumscribed by a global approach that will define it through successive inward 'zooms'.

The path of a composer who seeks both to express himself and—in the strongest sense of the term—to create should follow a succession of intuitive and theoretical steps that reinforce each other. We have certainly sought, after rather intuitive phases, 'objective' bases to renew composition, in contrast to arbitrary systems, or to the resignation of those who eschew all systems. Looking back, one might say it was a question of understanding the natural rules of the organization of sounds, then of formalizing those rules, making generalizations, and from these observations creating a vocabulary, then a syntax, and finally—why not?—expression.

But sounds—and, moreover, the relationships between sounds—have an acoustic and perceptual reality that are not necessarily identical: the study of this 'sense' I described above is an object of psychoacoustics and of perceptual psychology. One could hardly be unaware of this. Take, for example, the perception of time. For all that I was tempted, I find attempts to align our musical time with that of Hindu or Javanese culture ultimately fallacious. The concepts of dynamic music, of fluid time, etc. are too deeply rooted in our culture to be simply swept aside by the work of a single person. The result is that our cultural heritage—and our apprehension of sonic phenomena that science, as described above, has revealed to us—is for me a part of musical material that I must use, just like the great range of sounds offered by past and present technology.

The current explosion of possibilities within the world of sounds, and the techniques for investigating them, naturally challenges traditional compositional systems. Limitations disappear, pre-existing classifications lose their meaning and phenomena once considered distinct now appear continuous. The analytical approach (the decomposition of sound into parameters) no longer holds, and the traditional processes of western music—combinatoriality, counterpoint of lines, permutations, imitations, etc.—lose their power when faced with these continuous phenomena. A generalized approach becomes necessary to attempt to understand sound in all its complexity, all its freedom, to create the rules of organization required by any act of composition. But these rules need not be incompatible with the nature of sounds; we must accept the differences, the hierarchies, the anomalies, and resist, as much as possible, reductive analysis.

The craft that takes sound as its point of departure is not a pursuit of 'beautiful sounds' as is sometimes alleged. It rather tries to create a method of communicating clearly with sonic material; timbre is simply one of sound's most charged and recognizable categories.[3] Here lies the importance to musical discourse of combinations of frequencies (which produce timbre). Of course, one can find examples of spectral music with 'beautiful sounds', but spectral music has also bestowed the history of music with some of its most atrocious noises. Really, it is not the intrinsic quality of a sound that matters; what matters is introducing systems of

hierarchy, magnetization or directionality into sonic phenomena in order to create a musical rhetoric upon a new foundation.

Finally, it is for a certain kind of abstract music that a brilliant orchestration will paradoxically be particularly advantageous, and sometimes necessary, for without these trappings it will be either incomprehensible or uninteresting (think, for example, at attempts at the serialization of timbre). On the other hand, spectral structures often have a meaning outside of orchestration; they possess a certain plasticity because they are themselves drawn from the internal organization of timbre. They lend themselves as easily to sine wave realizations (by definition, of course) as to realizations in richer instrumental timbres, which produce effects of spectral multiplication. They are sufficiently pertinent and elastic to endure various treatments or tortures with their identities intact. They allow for games of memorization and recognition that are generally disallowed to combinatorial composition, since the configurations created through the latter's permutations are rarely salient or memorable enough for them to work. Here we have a central property of spectral structures: they allow for the production, at will, of timbre or harmony without conflict or redundancy. This property is liberally exploited in works mixing electronics with acoustic/instrumental sounds (e.g. Grisey's *Jour, contre-jour* and my *Les Courants de l'Espace* and *Désintégrations*).

We often take composers preoccupied, if not with form per se, at least with a kind of dynamic sensibility, and contrast them with those who find immediate pleasure in sound, but who minimize, perhaps, formal craftsmanship. At least one of these orientations is certainly necessary. And it is the dynamic sensibility that prevails, that redeems Beethoven's moments of awkwardness or Xenakis's failing ears—just as, if we pursue the metaphor, we can immerse ourselves in the static (eternal?) time of Messiaen to the point of losing touch with his formal austerity. As for me, I see no reason to contrast these two conceptions, and my ideal (which I do not pretend to always reach) is to melt them together. That is the goal of a spectral music based at the same time on sound and process. Even better, we can *extract* dynamism from sound. Or we can use a strict dynamism to construct sounds and—why not?—sonic pleasure. With sound we can create, in sum, an architecture.

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Our approach carries no proscription. In other words, it's not defined negatively against some other system of composition. For me, theory can only develop through the observation of some practice—whether of composition or experimentation. Theorizing (or, more modestly, systematizing a practice) may eventually give rise to extrapolations worthy of further experimentation, from which we return to practice, creating a true practice/theory dialectic. If, then, I am refusing anything, it is above all the notion of any a priori refusal: the compositional system masquerading as axiom.

This does not mean that anything is possible, but that selecting one out of many possibilities should occur in a positive manner, as a consequence of creative processes, rather than through processes of censorship and elimination. I can

mention a simple example that I have gleaned from observing 'serial' scores—not that my point is to criticize serial techniques. To structure a score around a series is certainly a positive process (even if the original impulse is arbitrary); on the other hand, the actual practice of many serial or serially influenced composers is quite different. They more or less have abandoned a strict concept of the series; what is ultimately preserved is solely a system of negation (avoiding certain intervals, certain aggregates, certain formulations) that, in any case, will effectively assure the work's coherence.

I do not believe, therefore, that one can speak of a 'spectral system' as such, if by that we understand a body of rules that will produce a product of a certain hue. I do believe, however, that one can speak of a 'spectral' attitude. Our attitude before musical and sonic phenomena was briefly dealt with above. The compositional practice that is derived from this attitude constitutes, perhaps, a method that will above all provide an orientation preventing us from losing ourselves in a universe now without limits, without rules in the geometric sense, a universe that is no longer quadrate, subdivided into reassuring reductive categories, but a universe of continuity and complex interrelations. It is clear that we are very far from the simple pursuit of a 'new consonance' or a search predicated solely on the vertical, reaping sonic pleasure (which, of course, should not be prohibited either).

To properly find a place in the 'spectral' universe, it is not enough to align a few harmonic series, neatly packed; above all, one must have a certain new kind of awareness of the musical phenomenon. This stance translates into some essential precepts (the list is not complete), including:

- thinking in terms of continuous, rather than discrete, categories (corollary: the understanding that everything is connected);
- a global approach, rather than a sequential or 'cellular' one;
- organizational processes of a logarithmic or exponential, rather than linear, type;
- construction with a functional, not combinatorial, method; and
- keeping in mind the relationship between concept and perception.

The consequences of this change in perspective transcend the style of the first generation of 'spectral' composers. Many younger composers have already taken hold of these concepts and are finding new and very different results. Certain basic principles (process, interpolation, function, even the study of spectra) are now even assumed as self-evident by composers of many different stylistic orientations.

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Nothing justifies the a priori division of pitch space, that legacy of tonality and equal temperament if not, indeed, of history.[4] Nothing obligates us to trap durations within the grids that construct traditional rhythmic notation. These symbols are behind more than a fair number of absurdities and exaggerations. They are nothing but pale reflections of perceptible durations. Any categorization of timbres, of playing

techniques, seems suspect to me: we must remember that the relationships between phenomena are often more important than the phenomena themselves.

We nevertheless need tools that can handle the continuous expanses we have discovered. Pitches, therefore, will be measured by frequency (hertz), not by chromatic degree, and the continuum of frequencies will be controlled by the concept of spectra. Of course, one can argue that, like temperament, the spectrum is merely a latticework mapped over immeasurability. Any spectrum, in effect, creates grids, scales (always of unequal steps). What is crucial, however, is that these grids are the result of the composer's action, rather than a presupposition.

A spectrum is a grid that allows for compositional practice and, at the same time, allows for the material itself—the mode and the theme at the same time, to make a risky analogy. It is in this way that the form–material distinction will become obsolete: the content tends to identify itself with the container. Depending on one's point of view, the spectrum will remodel itself as melody (neumes), harmony, timbre, even rhythm in certain extreme cases, or it will assume an ambiguous identity. Ultimately, it is better to consider the spectrum not as a new type of grid, but as a field of possible relationships within a group of frequencies: an ensemblist conception, as a mathematician would say. This conception may extend to all manifestations of the musical discourse: a spectrum is an ensemble, a sound is an ensemble, a form, a microform, an orchestral figuration, a group of durations; all of these are ensembles upon which ensemblist operations can be performed.

This article is not the place to examine the different species of spectra (harmonic, inharmonic, 'nonlinear', etc.), nor the different operations that can be applied to them (proliferations, metamorphoses, derivations, superpositions, interpolations, etc.). We shall retain above all the fact that the spectrum offers at the same time material and a frame, in the form of a network of relations among which one may choose, but within which one must remain, if one wishes to respect the rules of the game and, in so doing, guarantee the necessary harmonic and discursive coherences. I should add that, unlike the harmonic fields that are so often substituted for a series, spectra, like musical sounds, are rarely static; they themselves are subject to processes that continually alter their aspects.

An opposite approach is possible: constructing a spectrum with the requisite qualities to express a formal structure or a musical gesture. For this, one would have a certain amount of tools (imitation of 'natural' spectra, construction of spectra through calculations or through using functions, treating spectra with filters, distortion, modulation, etc.). Spectra are often constructed through the development of a formal process (see Example 1).

Obviously time must also be considered in its continuity—the unit of measurement, then, would be the second rather than the quarter-note. The notion of duration will become very generalized, extending from individual durations of events, to the space between events possessing similar features and precise moments of onset (which one generally calls rhythm), to tempo itself. The discourse will be identical to that for pitch: the absence of a priori segmentation; the lack of subjection

to solfège figures; a refusal of complexity stemming from the superimposition of *n*-tuplets or irrational meters as useless as they are arbitrary.[5] The calculation of duration resembles to a great extent the calculation of frequencies (the use of functions, distortions, interpolations, processes, etc.).

Graphic methods can control durations more easily than frequency. Graphic methods of controlling frequencies cannot really cope with the complexity of interrelations at the heart of an aggregate, but durations require a lesser degree of precision; a sense of the relationship between durations can be gleaned with a simple glance. The graphic methods I use for duration are of two types: simple graphs of functions drawn freehand (over given or calculated points), and spatial representations of an episode. This latter almost amounts to a map of the work, preliminary to its definitive realization, where all the essential information, other than the purely spectral material, is assembled.

It is in this way that a global type of approach—an essential element in the spectral method—is designed. Ideally, all is amassed within it, and any variation in scale, duration, frequency, density, etc. will instantly alter the overall equilibrium. Modifications impact the overall structure incrementally, like cells in a computer spreadsheet. There are no 'non-temporal' structures because nothing is imagined outside of time.

It is certainly on the temporal level that this question of interrelations has its most marked effects. In my music, durations are almost always tied to each other via functions; the duration of any episode, any process, can be analysed in terms of the sum of elementary durations. Episodes are also tied to each other via relations. Any adjustment of an individual duration will thus have a repercussion on the global form (e.g. evolution of a density + evolution of the average event speed, or proportions of proportions; see Example 3), and repercussions may be projected upon other dimensions of the discourse: melodic aspects, progressions of spectral parameters, etc.

Through successive approaches—like through a zoom lens—structures of smaller and smaller scale are created until the tiniest detail is reached. The fate of every individual note is preordained within the composition. But as the work (despite everything, and luckily) is not entirely automated, there are often choices to be made, and particularly interesting, suggestive or inventive groupings (of pitches or durations) to be identified. In this way, latent micro- and macroforms inherent within the original project are brought to light. I like to imagine myself as a sculptor in front of a block of stone that hides a form; a spectrum might, in this way, contain forms of various dimensions that one may extract under certain conditions—with certain tools: active filtering, selection of tempered pitches, spectral regions, formants, spectral exploration, etc. One of the major advantages of this conception is that the same technique can often be applied to different stages of a work's composition—its overall form, its sections, figurations, sonorities—and to different dimensions of the musical sound, or to elements of the musical rhetoric (sequences, densities, registers, thickness, neumes, etc.).[6]

This compositional technique of progressing from the global level to the level of detail is totally opposed to classical techniques of construction starting with cells. Nevertheless, I do not think it is a question of engaging in polemics over the legitimacy of one approach versus the other; both clearly have advantages, and in any case, a composer's actual practice is often more pragmatic than his discourse or theory might suggest. And both approaches can sometimes unite, or reinforce each other.

There is one case, however, where the global approach strikes me as necessary: when one wishes to manipulate this new species that I have named 'complex sounds'. This category gathers sounds of new instrumental techniques (multiphonics, etc.), synthetic sounds (in particular, inharmonic sounds), sounds resulting from electronic treatments, and a large portion of percussion sounds. Complex sounds pose serious problems for traditional composition because they elude descriptions in terms of parameters; one either avoids them or reduces them to a single of their various dimensions, risking unexpected effects on the musical structure. There is no other way than to dismantle these sounds, to analyse them, to understand their structure, and to be able to handle them as ensembles (in the mathematical sense). It is the only way to manipulate complex objects, if one wishes to both respect them and deeply integrate them into the musical discourse.

Otherwise, one inevitably returns to empiricism, to the arbitrary, attitudes that must be considered paradoxical if one wishes to compose with a certain rigour. One does not have to use multiphonics on wind instruments or synthetic sounds; but who does not use percussion?

The lack of any real control over percussive sonorities (skin, metal, wood) often creates inconsistent effects in otherwise perfectly written scores. Percussion parts might be written solely along rhythmic processes, for example—the composer forgetting that these instruments always have spectral pitches, that they are clearly defined 'sonic objects', easily identifiable and limited in number. Perceiving these objects soon cancels out the perception of duration, while the fixity of their spectral pitches may contradict the harmonic discourse. For these reasons, I personally manipulate these 'sonic objects' with great caution and considerable discipline (as much as possible, given the imprecision of the instruments' definitions: what is the exact frequency band of a high cymbal or a low tam-tam? Just as microphones are defined by their response curves, the spectra of percussion instruments should be specified, and their characteristics should be standardized.)

Computers introduce a new dimension: interpolated, hybrid or ambiguous objects, and continua of timbre. Even the simplest process of working with frequencies will result in untempered aggregates and inharmonic timbres. Moreover, these sounds can be unstable or fluctuating: to describe these sounds, one must describe processes; for that matter, any sound, even one of a miniscule duration, is a process. Approaching electronic or computer generated phenomena with an inadequate compositional system frequently forces the composer to take refuge in static processes

(frozen harmonic fields, for example, which are found in so many recent 'mixed' works), which at least have the advantage of limiting the number of uncontrollable proliferations (as viewed by this type of composition), but at the same time lessen the motivation to solicit advanced technology.

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Speaking of harmonic fields, here is an idea currently shared by several musical styles: proposing a certain congruence between the vertical and the horizontal. Like a series—or some type of cell that hatches chords as well as melodies—a spectrum can be exploited both vertically and horizontally, with one possible advantage: the possibility of creating intermediate situations, within a kind of 'fractal' dimension, where perception can oscillate between various possible readings or simply surrender to the magic of ambiguity.

But let us not stop there. We can easily skip from the idea of the spectrum to that of the function or, more generally, the algorithm. Harmonic spectra, spectra bred of modulations (ring modulation or frequency modulation), spectra generated by harmonic distortions: these conform to relatively simple mathematical models. One can imagine processes by which the parameters of these models are modified, which would create harmonic instability or generate a number of different spectral images, as the cinema creates movement. Similar algorithms could easily govern all aspects of the musical discourse. The concepts of function and process are very close and could both be grouped under the rubric of algorithm.[7]

Confronting such flexible material, it is obviously necessary to find criteria that allow for the appreciation of sequences, mutations, rates of renewal, oppositions and similarities. Without a grid that applies to all manipulated objects, the problem is not easily solved. We would have little chance, for example, to find identical frequencies in two spectra—in other words, identical values in two lists of data calculated by a function. If we want to establish such types of comparisons, we must resort to approximations, consider effects of 'critical bandwidth', and exploit our charmingly imprecise faculties of perception. It becomes absolutely necessary to introduce the concept of hierarchy to perform these classifications from harmonicity to inharmonicity, from the smooth to the rough, from the ordered to the unordered. We should remember the specificity of each relationship of frequencies. Two simple examples: the octave has powerful properties, both acoustic and cultural in origin, that we must acknowledge—but is this reason to prohibit it? An interval is just a relationship between frequencies; however, mathematically, a/b does not equal b/a. One would never call an interval and its inversion identical, a little detail that could undermine a good number of the composers' and theoreticians' tricks. To acknowledge differences is not to cast judgement. 'Harmonic' is not a synonym of 'consonant'; 'ordered' is not a synonym of 'military march'. One finds equilibrium within both relatively orderly situations (harmonicity or periodicity) and their exact opposites, like noisy sounds or rhythmicized noise, of which one definition would be 'integral disorder'. Any intermediate situation carries with it, to some extent, a

disequilibrium, that introduces the phenomena of attraction and dynamism discussed above; composition consists, on one level, in managing this disequilibrium.

Exploring these hierarchies brings up what I call the 'vectorization' of the musical discourse, that all processes have a trajectory and imply a directionality (*sens*), if not a meaning (*signification*)—the listener is well aware that he is being taken somewhere, and that there is someone in the driver's seat. This vectorization inevitably creates feelings of tension and relaxation, of progression and stagnation; it plays on the comfort of the expected and the pleasure of surprise, whether through threshold phenomena or through subtle U-turns in underlying general trends—in a word, it creates the dynamism of the musical discourse. It is this aspect—not compositional trends or any stylistic fashions, not superficial revolutions and sterile polemics—that speaks directly to the cognitive categories of the western listener. It is ultimately on this level that I would like to compose. Indeed, if the analogy of a compositional language ('*écriture musicale*') means anything, then it is from this level that I hope to draw my vocabulary and syntax. Modelling is a great help in freeing music from the quicksand of note-by-note composition, just as generalized graphic notation, rather than solfège notation, helps in sketching a work: ideographs, say, rather than alphabetical characters. I believe that only the computer can help us pursue this direction; only the computer will grant us the necessary degree of freedom to maintain the conceptual work with the attitude we want, freeing ourselves from subaltern duties, helping us govern the networks of interrelations.

The development of both conceptual and practical tools forms the condition for a deepening of the technique of spectral composition as it has been defined here. To directly compose a process, its variations, its complications, quickly exceeds the capacities of the human spirit. I am very aware of the fact that up until now we have remained at a relatively elementary stage of using these techniques; the wish to be understood has led us to very direct and immediate processes; we had to experiment, and perhaps also we had something to prove. We did, however, face the question of predictability early enough; of the eventual necessity to free ourselves, at least at the right moment, from the domination of overly directional processes; to introduce ideas of variation or of ornamentation.

I started by using aleatoric processes and processes of limited permutation, to vary at least the aspect of the processes. I found multiplying functions lent more interesting aspects to curves I used (by combining, for example, sinusoidal and exponential functions into an algorithm that determined the removal of components of the bell sonority synthesized by the orchestra at the beginning of *Gondwana*). Introducing randomness in order to 'humanize' mechanical processes is one of many elementary possibilities in computer-assisted composition. This 'aleatorization' can even extend to the synthesis of sounds themselves, to bring them more to life. Here is another example of a process brought to bear on both the macro and micro levels of the score. Randomness, when its rates and effects are controlled, softens processes without subverting them.

Classical procedures of permutation (like those Messiaen often used) tend to produce static results: constituent elements tend to turn in on themselves. But permutation of elements with an algorithmically derived series (e.g. exchanging certain values, two by two) will introduce an element of surprise or suspense while still adhering to the process's directionality. Example 1 illustrates such a restricted permutation of spectral distortions. Algorithmic or combinatorial procedures can themselves be written into the algorithm, at least when the elements are relatively simple. In *Désintégrations*, I often used this technique to control the order of 'wave tables' (these tables describe the components of spectra or the timings of micro-events; see parts III and IX of the score). From a set of general data (attack times of a sound mass, the type of permutation, the degree of randomness, etc.) the computer performed a detailed realization that was directly transmitted to the synthesis program. The computer calculations were then used to write the instrumental score. However, when it is a question of reordering series of spectra, as in the above example, the issue becomes quite delicate, since there is no way to predict how interesting the spectral/harmonic progressions resulting from these complex calculations will be: at least not with our present 'spectral' technology.

The superimposition of processes must be approached with similar caution. Processes governing at different scales may be superposed; more rarely, the combination of algorithms governs all aspects of the discourse at the same time. In these cases we have a true counterpoint of musics, and we know how difficult it is to realize this. On the other hand, limited overlappings of processes are common.[8] They often produce zones of indecision or rupture, liquescent or eruptive configurations like the shifting of tectonic plates. Such phenomena are produced when a process is carried out to its ultimate extreme: the material is then utterly transformed.[9] This replicates the trajectory already described: observation … generalized modelling … algorithmic development … engenderment of new objects.

Nevertheless, procedures of complication, generalization, of going to extremes, will increasingly distance us from natural modes of perception upon which we depend for a legitimate starting point. Interpolations, distortions, curves of various kinds; the manifold types of process used to map out transitions, to create directionality, to realize concepts or, simply, ideas or musical desires—all of these distance us from the initial postulates. Is this inspiring or alarming? Ultimately, we are beset with the same problems that face the combinatorial composer. Combinatorial calculations in no way guarantee musical values in themselves (although they can convey a certain vigorousness of process—like the cragginess of the late Beethoven quartets, or, in a more general sense, the astringency of dissonance and passing tones in tonal music).

If one wishes to operate upon selections, one must revert to the arbitrary—or to intuition, to the composer's expertise. I admit that I often tamper with the results of my semi-automatic procedures by eliminating a part here or there. With processes of interpolation or growth of a parameter, I calculate more data than I need so that I can eliminate certain steps that might conflict with my basic idea.

Developing one's method by this kind of elaboration, by modelling all gestures, by approaching limits, can end in contradicting the initial impulse, especially as concerns perception. The method, in other words, harbours the seed of its own self-destruction. But this is true for any system. My hope is that this method is sufficiently open, and that its lack of interdictions promotes an internal growth. But I do not want to make predictions about the development of a praxis and put myself forward as a theoretical legislator. Theory should serve to free us from habits, from needless repetition, reflexes and tics; it should not sterilize an approach. It should not justify useless complexity. Ultimately, the more I grow as a composer the more I value simplicity, the more complex simplicity appears, the more I see how simple it is to be 'complex'. Often, after long days of seeking a musical solution spent by complicating it, varying it, superimposing it, distorting it, perhaps masking certain weaknesses in a facile complexity—at the end of all this, I remorselessly eliminate all these gratuitous detours and the solution appears: simple, like any solution, but so costly in terms of creative energy. In my music, I am proudest of moments like these: when all is answered with a few sounds.

This is why it seems to be more important to assume a new *attitude* able to face (at least for a while) the surprises that the development of musical technique surely has in store for us, rather than a *doctrine* that, like any doctrine, must be doomed from the start (and doctrines seem to have shorter and shorter lifespans these days).

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An excess of theory or 'complexity' ultimately places too much importance to the written score and to its graphical aspect. I even remember a (celebrated) composer at a masterclass at the Royan festival who spoke of filling a page of staff paper until it pleased him visually. Even without going to this extreme, we do have a tendency to confuse the musical work with the score, to confuse the land with its map. Remember Borges: if the map is to completely represent the land, they must be congruent to the last detail. The map would *be* the land. Even now, we do not have the technique for such a representation. Even for tape music, where the score *is* the instrument, there are differences (the hall's acoustics, the quality of the speakers). We can always wait for direct neural stimulation, of course.

In the meantime, the score is still only a symbolic representation, an approximation, a coded message for the musicians, but not itself a musical phenomenon. In the extreme case, it is only tablature (e.g. Mâche's *Tempora*, for three samplers, or my *Tellur* for guitar). We find ourselves confronted with an apparent dilemma: precision of performance or notation? In fact, there is no precision at all. Creating and then hearing a work merely entails a parade of distortions: from the idea to the eventual form; from the form to the score; from the score to the performance; from the performance to the ear.

Notation is particularly problematic when it comes to rhythm. A series of durations—calculated in units of time, not noteheads, and derived from some kind of process—might be fascinating to the eye, might lend itself to further manipulation

(through the intermediary of a sequencer, for example). And it will not be impossible to capture it in notation, with temporal divisions or fragmentation, complex measures, tempo changes. But the finished score will be all but unplayable, especially by an orchestra—or at least the music the musicians perform will be considerably removed from the initial idea. If, however, I simplify the score (if I increase, in other words, the factor of approximation) while keeping in mind performance practices, I shall end up with a result closer to the original idea. It is a paradox: an excess of notational precision will erode the message it is meant to convey.

These are not new problems. The framing of musical ideas within an imperfect and intransigent notational system has long been counterbalanced by interpreters who know how to recreate the original ideas behind the score (I am thinking, for example, of Debussy's *Preludes*). This question becomes crucial for 'spectral' music, where timbre plays such an important role, from the timbre of individual instruments and the way they are played, to synthetic timbres created through fusion that depend upon a certain context. When a musician does not understand his role and simply performs 'note by note' without thinking of the global level in which he plays a part (or at least of the overall sound he helps to form), we have reached a true impasse.

Neither the score nor the performance, then, is the musical work. They are just representations of the work at different degrees of accuracy. It is within the sketches—the graphic schemas I evoked above, listings, algorithms, etc.—that we can rediscover the vestiges of the 'ideal score'. The essential thing in the journey to the written score is the preservation of relationships. One must find a homothetic relationship between the perceived music, the performed music and the written score without hoping for an exact equivalence. We also take into the account the ear's mechanism of auto-correction, whether physiological or cultural. These mechanisms exist for tonal music; they allow us to ignore the torpor of the seventh row of violins, to endure the nebulous intonation of opera singers, to put up with eccentric *tempi* of conductors. Experience has proven to me that auto-correction exists for spectral music as well; this fact justifies our use of approximations of pitches and durations as we approach the written score. I am not sure if this is the case for all types of music, which raises certain questions.

To rediscover the ideal score simply by looking at the written one is not always easy. We need certain clues for a deep comprehension of the work. Of course this can be said for any music, but it is relatively easy to identify a theme, a subject, a cell, a series; it is somewhat more delicate, although not impossible, to identify a spectral generation or the algorithm of a process.

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To take note of these successive degradations of the message is to address the problem of communication itself. To ignore the aural results of the composition act is, for me, a refusal to communicate. And, if composers no longer communicate, it is no surprise that the concert halls are empty. I willingly admit the validity of a

stance where it is the concept that matters; but in this case, why not go all the way and drop both the concert and the score? Rather than writing for 40 harps and 40 pianos, thereby adding to his already numerous difficulties, Berlioz was content to describe the idea (the 'Euphonia') in literary form. And, rather than writing novels, a practice that bored him, Borges simply wrote fictional critiques of them that expressed their essential ideas. Truly conceptual art should not move past the conceptual.

Choosing a mode of communication is not without aesthetic consequences. Devotees of neo-romanticism (the 'new simplicity') write for the classical orchestra public, while those writing 'paper music' address juries of international composition contests before anyone else. One might ask whether in such extreme cases there is any real communication between the composer and the target audience. In the case of neo-romanticism, the code for communication becomes identical to the musical material itself (one could argue much the same thing for rock and its derivatives). In the other case, that of 'paper music', both communication and code have disappeared; all we are left with is the crafting of symbols, even just of graphics, disconnected to any aural application. It is like Parkinson's Law (with enough employees, a company can keep itself fully occupied with internal administration requiring no contact with the outside world): with sufficient conceptual or combinatorial proliferation, the score-object gains self-sufficiency and no longer needs sonic reality. It is, in other words, nothing (except perhaps a package to be FedEx-ed to the juries mentioned above) to be commented upon, or imitated.

For me, music exists only at the moment it is heard; but it is often *heard* symbolically, by the composer, for example, at the moment he conceives it, and then over the long chain of distortions that finally lead to its public reception. It seems essential to me that this homothetic relationship between the composer's concepts of the 'ideal' score and its audible result is maintained. This is where acoustic and cultural factors become important, even leaving their mark on the compositional technique. We must resist the illusion that our public is a universal one: it is a Western one, built up over centuries of musical practice. It should be reasonably open and alert, if communication is to be established. I hope, however, that it is not limited to our circle of colleagues and international juries. But I also hope to be able to express myself freely, without heeding conventions, prejudices and conditions. And this hope implies certain consequences, raises certain questions.

Can the unknown be heard? How do we introduce the new? A politics of *tabula rasa* is illusory: we cannot ignore the past without reverting to Neanderthalism. On the contrary, I think that what history has bequeathed us—in other words, our culture, our mental functioning—far from imposing restrictions, forms part of our musical material just as much as known or imagined sounds, and can be integrated with every degree of freedom into a new discourse. But we must remember, as well, that the search for the new, the rejection of systems viewed as outdated, ruptures—these also form part of our

culture, as opposed to many others where stability is the rule and the musician's margin of creativity is strictly delimited by a secular practice. It is this very duality that should allow us to create a new musical discourse with absolute freedom and intelligibility, without nostalgia or neuroses.

Example 1. Modelling and Generalizing an Observation. Calculations of Durations and Permutations[10] in *Désintégrations*

At figure X of *Désintégrations*, after having followed a complex process that began at figure IX, the music converges upon an E2 repeated by the *ff* trombone. After a rocking movement, during which an accented G2 (resulting from the same process and played by the bass clarinet) reluctantly disappears, the trombone stays on alone.

The tape then plays a defective (filtered) spectrum that emerges from the trombone's sound. Actually the spectrum's fundamental is E1; the trombone plays its second harmonic (Figure 1).

As elsewhere in the piece, this spectrum will be sustained and progressively distorted. This particular distortion was drawn from observations of piano spectra: analysis has shown that the piano's sound is not perfectly harmonic; its partials are higher than harmonic theory affirms, and a partial's deviation is a factor of its number. (This explains much regarding the instrument's brilliant sonority—its characteristic sound—and much regarding the piano's repertoire.)

With a mathematical function, we can create a model of this phenomenon. I used a power function ($y = ax^b$) rather than an exponential one, whose ascension would be too rapid.

In the piano's case, distortion is quite faint (b is barely above 1). But we can extrapolate from this by increasing the value of b, creating a whole new series of inharmonic spectra.

Rather than working directly with the function's parameters, however, I prefer a more intuitive and musical approach to the distortion process. I therefore set up reference points, like plotting the evolution of a single harmonic. In this example, I chose the 12th harmonic and decided, to control the overall process, that it would ascend in steps of a quarter-tone. Software then calculated the parametric variations

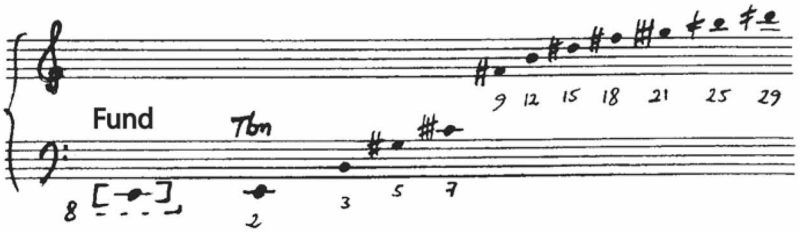

Figure 1 Filtered spectrum.

in the function that would provide this result, and finally it calculated the spectra themselves (Figure 2).

In these examples the partials of the spectra are approximated to the nearest quarter-tone. Since they are played on the tape, approximation was not really necessary (the computer produced the exact frequencies directly from its calculations). But the approximations helped the instrumental writing, which here is rather restrained, to reinforce certain formants.

The rhythm underlying the spectrum's rate of change is determined by a curve of acceleration; this function is of the same type as the one controlling distortion.

At the end of the process, tension has reached a breaking point, and a 'threshold effect' occurs: the music flips into another process. The first spectrum of figure XI was derived through a process akin to the 'linear regression' of a statistician: while close to the spectrum at figure X, it is harmonic, and thus much lighter; it suggests both continuity and a sudden change in hue (Figure 3).

Further generalizing the idea of spectral distortion (or for that matter the idea of constructing spectra through a function), we can abandon any reference to instruments; in the last example, the trombone's presence created the impression that the process of distortion was referring to instrumental sonorities. At figure VII of *Désintégrations*, we hear a series of seven spectra derived from an entirely arbitrary process of distortion. The reference points of this distortion are the 3rd and 21st harmonics that evolve by half-step and quarter-tone respectively, producing a translation and progressive compression of spectra (Figure 4).

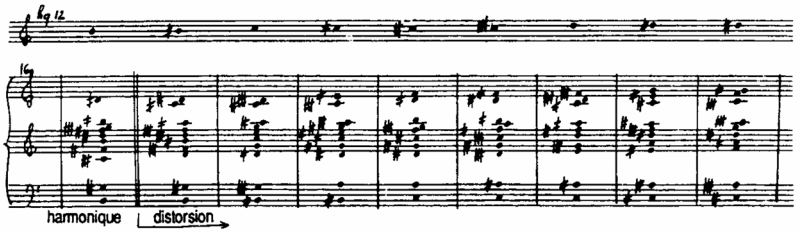

Figure 2 Progresssive distortion controlled by the ascension of the 12th harmonic.

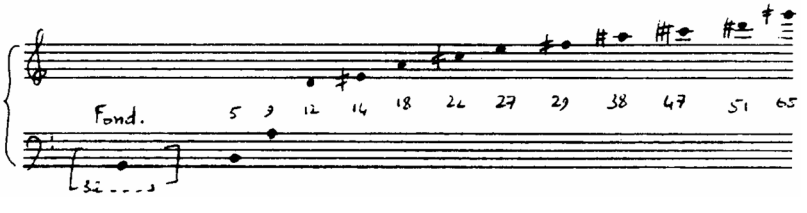

Figure 3 Spectrum used to produce a sudden change in hue, as figure XI.

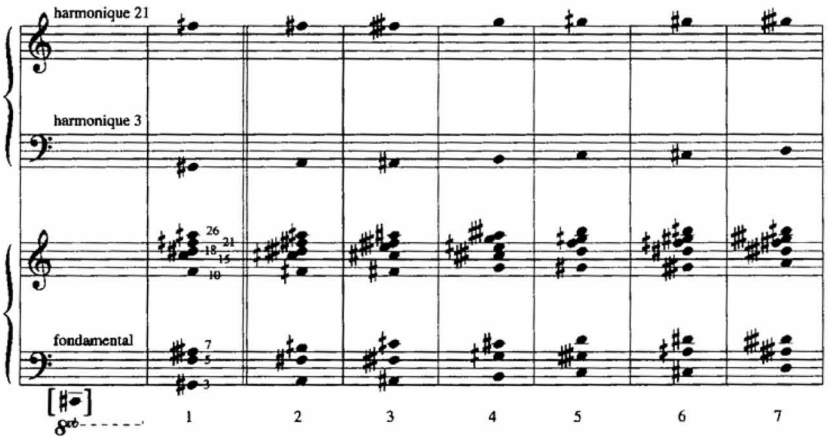

Figure 4 Translation and progressive compression of spectra at figure VII.

Each spectrum, heard on the tape, moves through space (spatial vibrato) with increasing rapidity, following this curve (values are in Hz):

0.2326 1.2534 2.861 4.8 7 9.4 12

The number of oscillations follows this evolution:

1 3 4 9 3 6 45 (ascending curve, in irregular values)

By multiplying the number of oscillations by the period (the inverse of the value in Hz), we obtain the duration, in seconds, of each spectrum:

4.3 2.4 1.5 1.9 3.3 2.8 3.8

By combining the two curves, we can see a new profile has been created (decreasing, then increasing irregularly).

This explanation probably does not correspond to the actual composition of this passage (I forgot the order of the operations), but shows the interrelations as one observes them.

The seven spectra are not, however, ordered in terms of their distortions, but are slightly permuted: 1 4 5 2 6 3 7. This reordering brings a bit of unpredictability to the sequence while preserving its general direction.

Next, the ambits of the spectra were moulded to create an 'accordion' effect. To preserve a similar density for each spectrum, it was necessary to filter certain components, or fill in certain spectral zones, producing the final result shown in Figure 5.

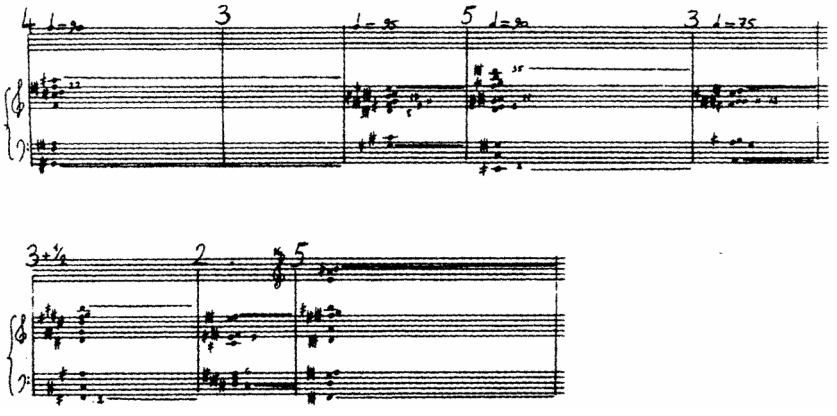

Figure 5 Chord sequence at figure VIII.

Example 2. Interrelations in *13 Couleurs du Soleil Couchant*

Upon first listening, *13 Couleurs du Soleil Couchant* might seem like a fairly 'impressionist' work, but in fact it is a highly predetermined and calculated composition. Almost the entire work stems from an initial project materialized by similar curves governing frequencies, durations and pulsations. The 13 colours of the title correspond to 13 generative intervals which are narrower the higher their registers (with a few exceptions) (Figure 6).

Next, we can trace the design shown in Figure 7. It was necessary to add an introductory sequence, not shown in this figure, based on a single tone (E6): an interval of the unison. The tools of control are often of a statistical nature ('average pulsation'); this means that the directions of the processes are always controlled, but that certain freedoms can exist at the detail level, almost like ornamentations—or that other processes can interfere at the local level.

The intervals are managed so that they lead from one to another along different types of linkages or by spectral proliferation. Figure 7 illustrates the harmonic evolution from section 1 to section 3. At figure 1A, the first interval has not yet appeared; the cello, playing *alto sul ponticello*, decompose the E-flat 4 into a harmonic spectrum (highlighting the strong presence of the 5th harmonic, G6, that anticipates the G5 of the first interval).

At figure 1B, the clarinet decomposes the E-flat once again, this time in a much clearer way, to produce G5. The violin breaks away from the G, gliding gently a quarter-tone away; amplitude ('ring') modulation between the G quarter-sharp and the E-flat produces the new frequency B4 and the addition of that B4 to the G quarter-sharp 5 produces the E6; the B forms, with the E-flat, the new generative interval (δ et σ represent the differential and additive tones respectively).

The same games of modulation are played out in section 2. Here, the piano approximates and accumulates some of the frequencies present. They could be

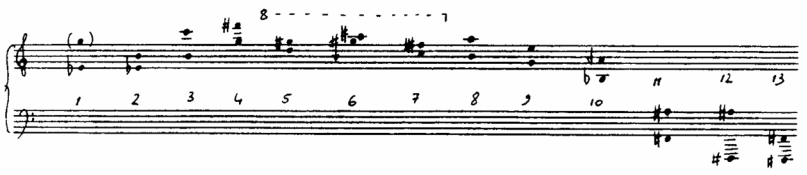

Figure 6 The 13 generative intervals.

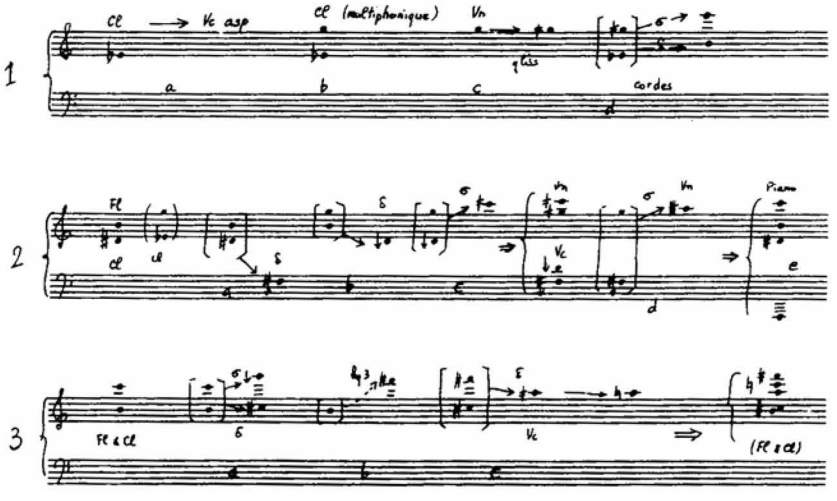

Figure 7 Harmonic evolution from section 1 to section 3 (there is an error in section 1 of this figure: the final E6 is the additional resulting sound from the combination of the G quarter-sharp 5 and the B4).

considered, then, approximate harmonics over the fundamental F1 also played by the piano.

The third interval is produced from the piano's chord; we once again use modulation (3a) or harmonic relation (3b), etc., to derive material.

The writing of the instrumental parts can fully organize themselves with a framework rigorously defined as in the above description. Melodic figurations, for example, make use of the frequencies at hand while respecting the pulsation value of the particular section.

Example 3. Schemes of Proportions and Evolutions of Parameters in *Gondwana*, for Orchestra, rehearsal letter F

Here the music follows the model of frequency modulated sounds, whose spectra develop by augmenting the modulation index. The music essentially consists of a series of waves calculated by frequency modulation; the form of the series is produced by varying the modulation index, which creates figurations (Figure 8).

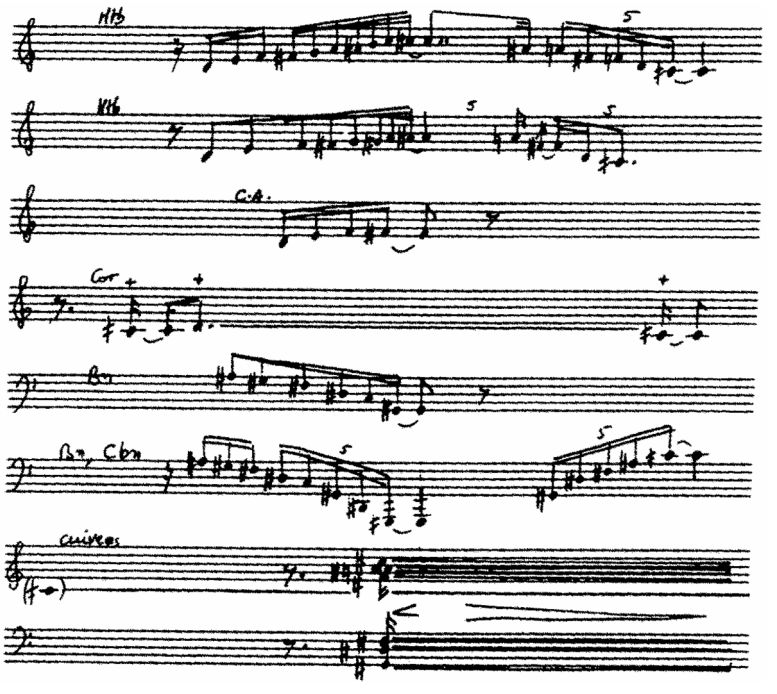

Figure 8 Figurations created by varying the index of modulation.

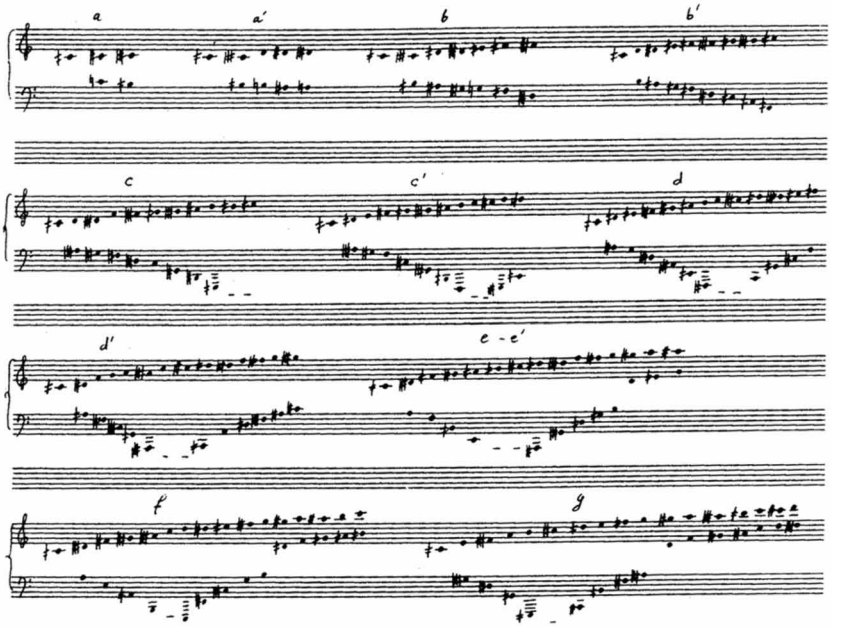

Figure 9 Frequency modulation 'waves'.

The waves occur in pairs. Their durations decrease until figure E and then begin to grow again. The length of the second of each pair of waves continues to grow, infringing on the first, until the two are nearly fused. The sonority of the first wave

Table 1 Evolution of parameters in *Gondwana*, rehearsed Letter F.

	length of pair	relation 2nd wave/pair	length of wave	modulator (hz)	index
a	31.6	0.57	13.6	7.88	2
a′			18	12,75	4
b	25.7	0.591	10.5	17.92	6
b′			15.2	22.49	8
c	18.2	0.615	7	27.36	10
c′			11.2	32.33	11
d	9.4	0.627	3.5	37.10	12
d′			5.9	41.97	13
e	4.9	0.633	1.8	46.84	14
e′			3.1	″	″
f	7.5	/	/	51.71	15
g	14.5	/	/	56.58	16
h	23	/	/	″	″
i	37	/	/	″	″

e and **e'** share the same modulator: the fusion between the two waves of each pair begins in this manner. Starting at **f** the two waves are almost completely fused, the second wave becoming a sort of echo of the first. **h** and **i** use the spectrum of **g** which is progressively filtered.

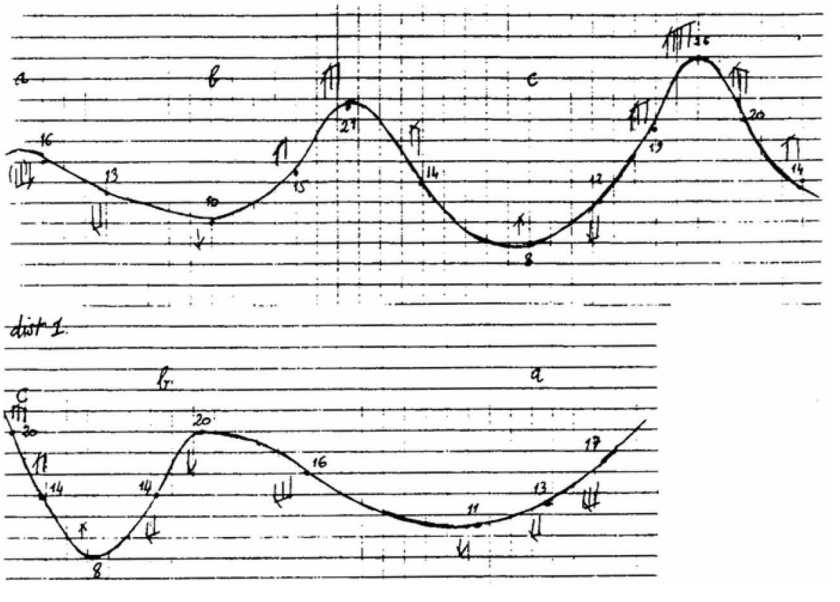

Figure 10 Melodic line of the French horn in *Vues Aériennes* inscribed within a harmonic spectrum and three distortions of it.

tends towards the resonance of brass instruments, while that of the second approaches the resonance of *tremolo* strings. At the same time, the modulator increases by steps of 4.87 Hz and the index by steps of 1 or 2. The carrier, embodied in the held tone of the horn, is fixed at C quarter-sharp 4 (Table 1) (Figure 9).

Example 4. Rhythmic and Melodic Elaboration in *Vues Aériennes*, for Horn, Violin, Cello and Piano, Section IIIB

This section uses a harmonic spectrum that recurs throughout the piece and three distortions of it. The horn's melodic line is inscribed within these spectra; the strings

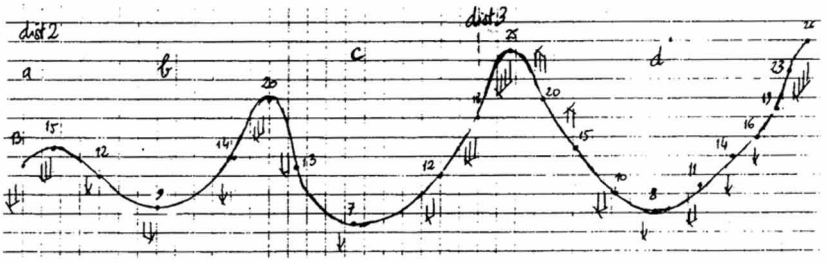

Figure 11 Melodic line of the French horn (continued).

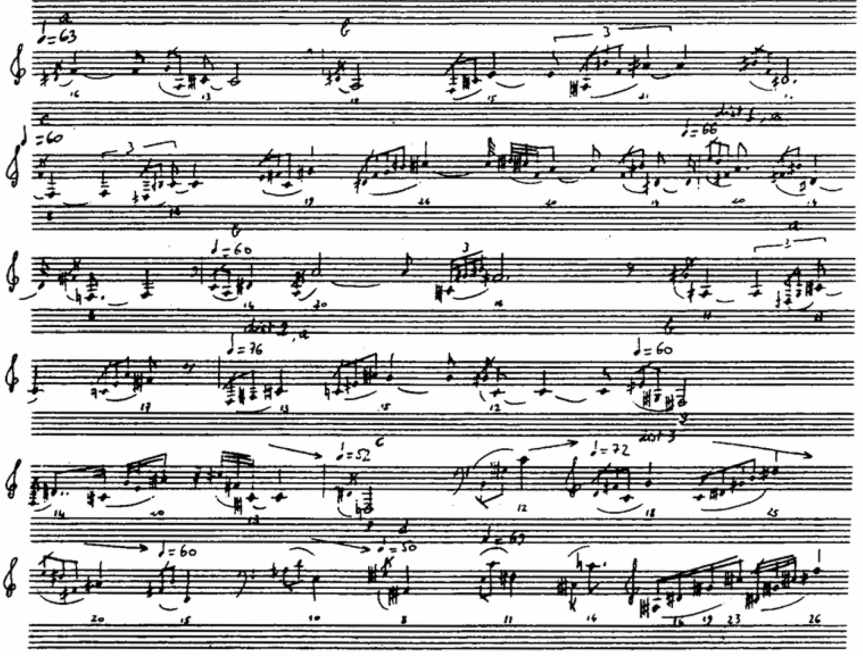

Figure 12 Musical transcription of the line.

respond by shifting the spectra by an octave; the piano plays the horn's harmonics in the extreme high register. The horn part was determined by designing a curve evoking a sinusoidal function of variable amplitude and 'frequency' (time is on the *x* axis, the partial numbers are on the *y* axis). The principal notes correspond to the extremities of the undulations and to intermediate points in increasing number on each ascending or descending portion. They are animated by groups of *appoggiatura* whose number of elements depends also, with some irregularities, on the design of the curves. Durations follow the same scheme. The waves tend to increase in both dimensions, but as the number of intermediate points increases the durations become on average shorter; they are longer when they correspond to the troughs of the waves. To counteract the rigidity of the process, the fragment of the wave that corresponds to 'distortion 1' was reversed along the temporal axis. The numbers correspond to the partial number of each principal note (Figures 10, Figures 11 and 12).

Notes

[1] Editor's note: This article was originally published in French as 'Questions de cible'.

[2] Very generally, that which is sensed, in other words, perceived and interpreted.

[3] Even the least musically minded listeners are capable of recognizing an instrument. Most of today's pop music plays with timbre above all; what creates a successful rock group is not melodic, harmonic or rhythmic content (this is generally hackneyed), but a characteristic 'sound'.

[4] It is possible to turn my position vis-à-vis culture's influence on perception against me and argue that temperament is not arbitrary because it forms part of our collective musical consciousness. Studies have shown, however, that non-tempered aggregates (at least those produced through the spectral method!) are not perceived as 'abnormal', but often appear more 'correct' than their approximations in semitones. The resistance to non-tempered pitch space is found to the greatest extent among professional musicians who would prefer not to question their education.

[5] The uncontrolled use of 'irrational' values yields results that are in fact unperceptible (e.g. if the quarter-note equals sixty, the difference between two-fifths of a beat and three-eighths of a beat is equal to 0.025 second). Our perception of durations is in fact very inaccurate and totally relative; by contrast, we can perceive extremely tiny differences of frequency (differences as small as one-thirtieth of a tone!). Moreover many musicians have perfect pitch.

[6] The old utopia of 'integral serialism' (congruence of the microcosm and the macrocosm, congruence of the treatments applied to different parameters) finds itself realized here, in a different and unexpected way, according to a generative logic and with perceptible results—allowing for communication.

[7] Let us take a very simple example to illustrate this point. A harmonic spectrum follows the relation $h = fr$ (where h is the harmonic, f is the fundamental, and r is the overtone number; h and f are expressed in hertz (Hz), r is an integer). This is a *function*. Let us imagine a process of filtering: we keep one out of every three harmonics starting with the fifth overtone and ending at the twenty-third. This filter is very easy to code in a number of programming languages by writing a reiterated loop. By doing this, we have created an algorithm. Now, if we imagine progressively eliminating the excluded harmonics *over time*, we are imagining a *process*. If this elimination can be captured in a model, we can describe it through a very simple (if I can use the word) complication of the preceding algorithm.

[8] See, for example, *Gondwana*, bar 9 after letter E, where one process slowly ends while another starts; the two overlap for quite some time. The granular sounds of E9 begin to be articulated individually, then are gradually enlarged or explored as individual sounds. This process is embodied within a sequence of more and more languid orchestral structures. Within the gaps between these structures appears a brass pitch (C 1/4 tone sharp), around which forms a series of expanding waves of frequency modulation that eventually overtake everything. The processes that govern these waves are analysed in Example 3. The F harmonics of the flutes (F10 – 11) form the last vestige of this process.

[9] This kind of metamorphosis is well known to fans of frequency modulation, which produces the phenomenon of foldover.

[10] Examples are drawn from *Désintégrations*, for tape and 17 musicians.

Reference

Marechal, I.-A. (1989). 'Miroir-Miroir'. *Phréatique*, *48*, 52 – 57.