L.H. Shaffer, "Performances of Chopin, Bach and Bartok: studies in motor programming." *Cognitive Psychology*, 13, p. 326–376 (1981).
J.A. Sloboda, "The communication of musical metre in piano performance." *Quarterly Journal of Experimental Psychology*, 35A, p. 377–396 (1983).
J.A. Sloboda & D.H.H. Parker, "Immediate recall of melodies." In P. Howell, I. Cross & R. West (Eds.): *Musical Structure and Cognition* (Academic Press, London, 143–168, 1985).
M.J. Steedman, "The perception of musical rhythm and meter" *Perception*, 6, p. 555–569 (1977).
K. Stockhausen, "Structure and experiential time" *Die Reihe*, vol 2, p. 64–75 (1958; English edition by Universal Edition, London, 1975).
K. Stockhausen, *Klavierstück X* (Universal Edition, Vienna, 1957–1961, copyright 1967).
K. Stockhausen, *Kontakte* (Universal Edition, Vienna, 1959–60, copyright 1966).
K. Stockhausen, "How time passes . . ." *Die Reihe*, vol 3 p. 10–41 (1959; English edition by Universal Edition, London, 1975).
K. Stockhausen, *Zeitmasse* (Universal Edition, Vienna, 1955–56, copyright 1957).
J. Sundberg, L. Fryden & A. Askenfelt, "What tells you the player is musical? An analysis-by-synthesis study of music performance." In J. Sundberg (Ed.): *Studies of Music Performance* (Publications issued by the Royal Swedish Academy of Music No 39, 1983).
E.A.C. Thomas & N.E. Cantor, "Interdependence between the processing of temporal and non-temporal information." In J. Requin (Ed.): *Attention and Performance VII* (Erlbaum, Hillsdale, New Jersey, 1978).
N. Todd, "A model of expressive timing in tonal music." *Music Perception*, 3(1) 33–58 (1985).
M. Treisman, "Temporal discrimination and the indifference interval: implications for a model of the 'internal clock'." *Psychological Monographs*, 77(B), whole no. 576 (1963).
M. Yeston, *The Stratification of Musical Rhythm*. (Yale University Press, 1976).

Contemporary Music Review,
1987, Vol. 2 pp. 239–275
Photocopying permitted by license only

Tempus ex Machina: A composer's reflections on musical time[1]

Gérard Grisey
Dept. of Music, University of California, Berkeley, California, U.S.A. (composer)

This article is divided into three sections (the skeleton of time, the flesh of time, and the skin of time) and clearly distinguishes conceptual (or chronometric) time from perceptual (or psychological) time. The author firstly liquidates a few theoretical avatars such as rhythmic symmetry and then proposes a scale of complexity for duration that goes from order to disorder. The most important point is then addressed, namely, the absolute relativity of temporal perception which has become a function of the quality of the sound objects and the difference between successive objects. The degree of pre-audibility becomes the true musical substance of the composer. In the last section the author sketches out some problems of memorization as well as the complex relations that exist between the several times of the listener, the performer and the composer.

KEY WORDS conceptual time, perceptual time, rhythmic symmetry, relativity of temporal perception, pre-audibility, scale of complexity.

The skeleton of time

Definition

By skeleton of time we mean the temporal divisions that the composer uses to organize sounds. Without being immediately discernible, at best merely sensed beneath the "flesh of time", this infrastructure nonetheless retains an attraction for twentieth century composers, no doubt because in its relative simplicity it gives us the illusion of operational efficiency. The unit of measurement for this infrastructure is chronometric time, e.g. the second.

Rhythms and durations

Two approaches to rhythm may be identified:
a) by relating it to a given pulse, the meter, in the form of a periodic reference point. Into this area falls the rhythmic writing of Stravinsky, Bartok, jazz etc. Each rhythm is perceived in its qualitative relationship to meter (on the beat, off the beat) but also in its quantitative relationship to meter (longer or shorter than the beat).

b) Without a reference pulse we are no longer talking of rhythm but of durations. Each duration is perceived quantitatively by its relationship to preceding and successive durations. This is the case in the rhythmic writing of Messiaen and of the serialist school. In fact, a micro-pulse allows the performer or conductor to count and execute these durations, but it only exists as a way of working and has no perceptual reality. The more complex the durations (combinations of fractions of the unit), the more our appreciation of them is only relative (longer or shorter than . . .).

> Question: Doesn't Indian music achieve a synthesis of two systems: the first taking into account rhythmic macrostructures (talas), the second dealing with rhythmic subdivisions (rapid combinations of long and short notes)?

c) To remain consistent with the use of the second system, it seems unlikely that our quantitative perception could extend to the totality of durations that a piece of music comprises, but rather to a few durations adjacent to the one we are in the process of perceiving.

One can also imagine an oscillating rhythm in which the meter itself would fluctuate constantly. The moving reference point becomes its own objective and rhythm is abolished in favor of fluctuations in the pulse. This is one of the aims of my piece for six percussionists *Tempus ex Machina*. [2]

Some theoretical avatars and their importance

Twentieth century composers, like those of the fourteenth and fifteenth centuries, have speculated considerably about durations. They have applied to time the proportions identical to those one finds in spatial concepts: prime numbers (Olivier Messiaen), the golden section (Bela Bartók), the Fibonacci series (Karlheinz Stockhausen), Newtonian binomials (Jean-Claude Risset), and also stochastic procedures: kinetic theory of gases (Iannis Xenakis).

Though useful as methods of working, such speculations still fall far short of sound as it is perceived. *They became ridiculous when our elders ended up confusing the map with the lie of the land.*

Let us look in passing at some theoretical avatars of the twentieth century.

a) The notion of smooth (unmeasured) and striated (measured) time described by Pierre Boulez (1968, 1971) is merely the invention of a conductor bereft of any phenomenological awareness. Who perceives the difference between time divided up periodically by a meter (see Igor Stravinsky's definition, 1942) – or, if one prefers, by a virtual pulse maintained by the composer/musicians – and smooth time, without a pulse, if the rhythms which overlay it are there precisely to destroy all feeling of periodicity?

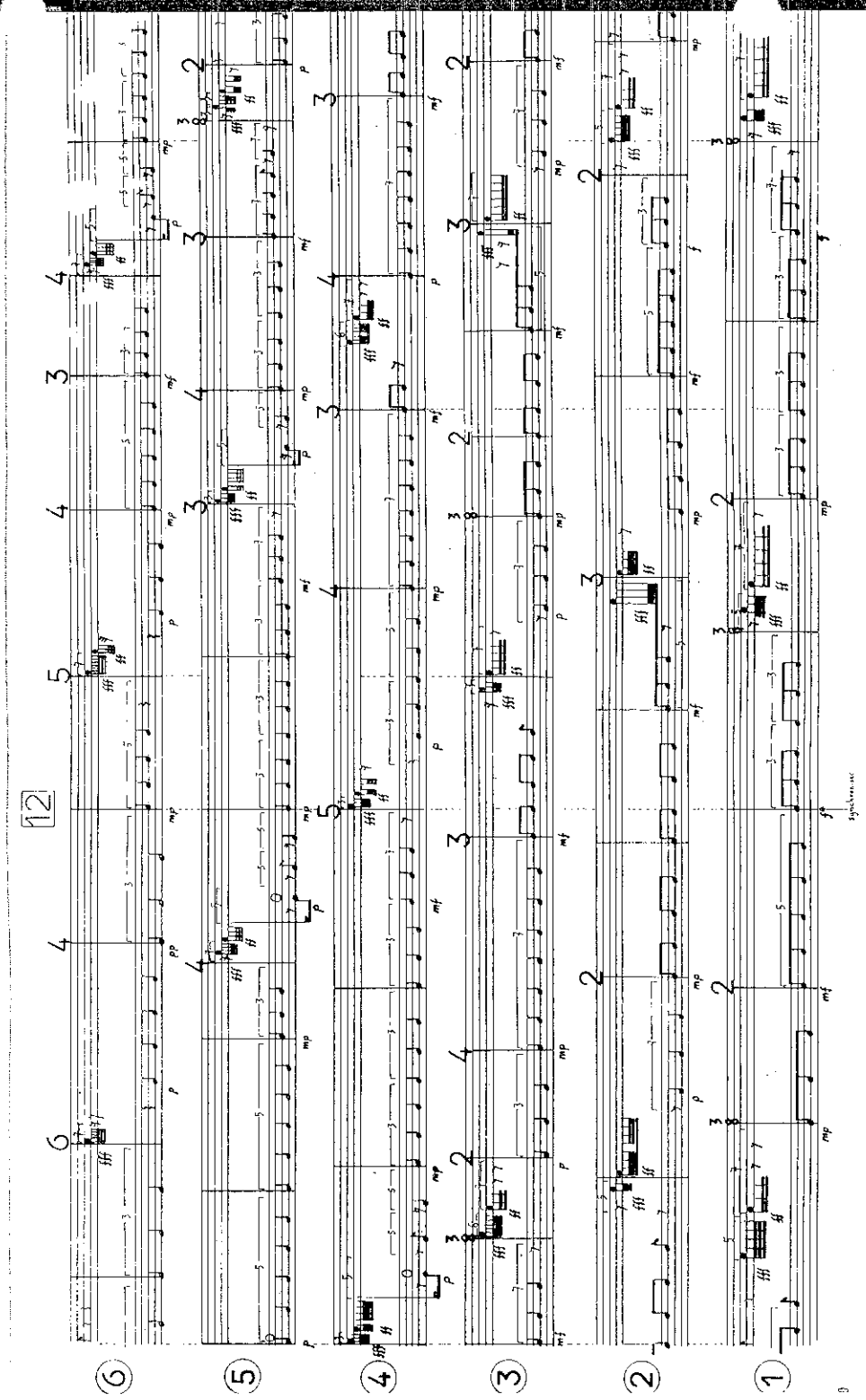


Figure 1 From *Tempus ex Machina* for 6 percussionists (p. 10). © G. Ricordi & Co., Milan.

Three examples:

Gruppen for three orchestras by K. Stockhausen (1963): the tempi have a great structural importance. Who perceives them?

Lontano for orchestra by G. Ligeti (1969): The tempo's only importance is as a point of reference, meant simply for conductors and musicians. Who perceives it?

On the other hand, *Stimmung* for six vocalists by Stockhausen (1969) shows us that only some elementary, even primary rhythms give us the very clear possibility of perceiving the tempo of these rhythms.

If, therefore, the pulse is not expressed, we will remember that only a few simple rhythms make the perception of a virtual pulse possible, whereas others disguise it for the sake of ambiguity and the mesmeric feeling of pure duration, without a reference point. *In the latter case, in the absence of any standard, each duration can only be compared with that/those preceding it,* and our apprehension of the durations is thus more global and more relative.

Perhaps because of this, the tempi in my music seldom have a structural value. More often, they serve to compress or expand a musical sequence, and it is therefore the total duration of this sequence which is structurally important, and not the unit of measurement.

Sometimes, however, tempi which become the basis of an elementary periodic structure take on a phenomenological value: see Fig. 1 above, *Tempus ex Machina* for six percussionists (1981).

b) Let us move on to another avatar:

The notion of retrogradable and non-retrogradable rhythms (Olivier Messiaen, 1956) or, similarly, that of rhythmic symmetry and asymmetry (Pierre Boulez, 1971). Again, such a distinction, whatever its operational value, has no perceptible value. It shows the level of contempt for or misunderstanding of perception our elders had attained.

What a utopia this spatial and static version of time was, a veritable straight line at the center of which the listener sits implicitly, possessing not only a memory but also a prescience that allows him to apprehend the symmetrical axis the moment it appears!

Unless, perhaps, our superman were gifted with a memory that enabled him to reconstruct the entirety of the durations so that he could, a posteriori, classify them as symmetrical or not! . . .

Or unless this were, once again, the business only of the specialist who *reads* a score! . . .

We can see clearly that, like the distinction between smooth and striated time, such distinctions only assume a phenomenological value in a limited number of cases that have yet to be defined; in this case, only short and simple rhythmic cells would make such a classification possible.

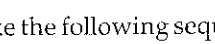
What a spatial view of musical time – but also what anthropocentrism there is in this image of a man at the center of time, a listener fixed at the

very center of the work to which he is listening! One might say that a truly Copernican revolution remains to be fought in music . . .

To return to the idea of rhythmic symmetry: if, for long sequences of durations, the sensation of symmetry is unrealistic, it nonetheless seems to me that there must still exist a means of creating such a sensation. Since the piece of music and the listener are two entities in time, we would have to imagine *an anamorphosis that would alter the symmetrical structures in such a way that their blurring in the memory were readjusted.*

Unfortunately, we are far from processing the psychoacoustic data for such an operation, but it is not unthinkable that we might eventually arrive at them.

With sequences of short durations, it would seem that we are more apt to recognize a symmetry by groupings rather than a genuine symmetry. In the way that we do not perceive single frequencies but attempt to group them in formations, so does the same apply to durations.

Let us take the following sequence: 

We would tend to group 

or 

and not 

because once we perceived it we would attach the short note to preceding or successive ones.

The same goes for: 

which we group a priori: 

because of the perceptible importance of the repetition of the first group

and not: 

Repetition is more salient than inversion or symmetry, to such a point that it can in certain cases assist the perception of these latter.

For example, the sequence  (symmetry by group) would certainly seem more symmetrical than the first sequence quoted.

With this reflection I have slipped unawares into the areas that form the subject of the next section. Back then to our skeleton!

Categories

In place of the arbitrary and generally dualistic categories which have been used in an attempt to classify durations: short/long, ternary/binary, rational/irrational values, symmetry/asymmetry, I substitute a scale of complexity – no doubt equally arbitrary – but which has the advantage of reverting to the phenomena of musical times as they are perceived and allowing a continuity to be grasped.

Information theory, such as that presented by Abraham Moles (1966) could be of assistance here.

From the following table we can construct a *continuum that can be found in the classification of intervals (by their degree of dissonance) and of timbres (by the extent to which they are non-harmonic).*

a)	***Periodic***	maximum predictability	ORDER
b)	***Continuous-dynamic***	average predictability	↓
1)	continuous acceleration		
2)	continuous deceleration		
c)	***Discontinuous-dynamic***	slight predictability	↓
1)	acceleration or deceleration by stages or by elision		
2)	statistical acceleration or deceleration		
d)	***Statistical***	zero predictability	DISORDER
	complete redivision		
	punpredictability of durations		
	maximum discontinuity		
e)	***Smooth***		
	rhythmic silence		

Before going over the elements of the table point by point it should be made clear that all sounds can be given a duration. By duration, musicians have too often intended a limiting meaning, such as the rhythmic expression of an attack transient. Climaxes of dynamic curves, changes in timbre, sound quality and vibrato, or, more generally, the actual form of a sequence or sound, constitute as much material as one can rhythmically express.

In the course of revising the present essay, Stephen McAdams drew my attention, quite rightly, to the fact that the degree of complexity as defined by information theory has very little to do with the degree of structuring and the way in which this structuring is actually understood by the listener.

It is true that perceiving the degree of complexity is neither as simple nor as linear as the preceding table might suggest. Between the perfectly predictable and the perfectly unpredictable, the degree of complexity seems to follow one or several curves whose peak(s) are entirely the

result of the musical context and the perceptual capacities of each person. One of the most arduous tasks for the composer will be to determine up to what point complex structuring affects perception in a non-negative way. On either side of such a point are two poles of boredom due to a lack or saturation of information, but this threshold is not any less dependent upon the complete subjectivity and responsibility of the composer.

a) *Periodic*

1) We do not consider periodicity as either basic material nor as the unit of rhythmic structure, but the most simple, most probable phenomenon; it is tempting to see it as an ideal point of reference for the perception of time, as is a sinusoidal sound for the perception of pitches, but not at all the a priori foundation of a hierarchical system. We would have as well the same attitude to consonance. However, if as Abraham Moles explains so well, "the notion of rhythm is linked to that of expectation" (1966), absolute, mechanical periodicity tires the listener as much as a ceiling or wall composed of perfectly equidistant tiles. We have all noticed how the periodicity of the synthesizer or computer in its perfect redundancy merely induces boredom and inattention.

The whole art of the composer who works in an electronic studio, analogue or digital, consists of making this excessively redundant material more flexible.

2) In 1973, with respect to a work called simply *Périodes*, I introduced the notion of fuzzy periodicity.

This involved composing periodic events which fluctuate slightly around a constant, analagous to the periodicity of our heartbeat, breathing or footstep. The rate of deviation can be almost inaudible (what jazz players call "feeling") or, if it is more marked, perceived as a slight hesitation in the periodicity (cf. expectation aroused in the music of Gagaku). I noted with great enthusiasm that here I was dealing with one of the areas of research carried out at IRCAM by David Wessel, psychoacoustician and composer.

> During a stay in Rome I was given to read the studies made by a team of German archeologists on the Greek temples of Paestum. The measurements of the pieces carved in the coffered ceilings showed an amazing variety in their repetition. The length of the pieces varied, if I remember rightly, between 23 and 29 centimetres!
>
> Question: What amount of systematic or statistical phase difference must be programmed to make electronic periodicity 'live' without also destroying the feeling of periodicity itself?

The psychological importance of periodicity no longer has to be demonstrated. Psychoanalysis teaches us that neurosis *is* a repetition: if

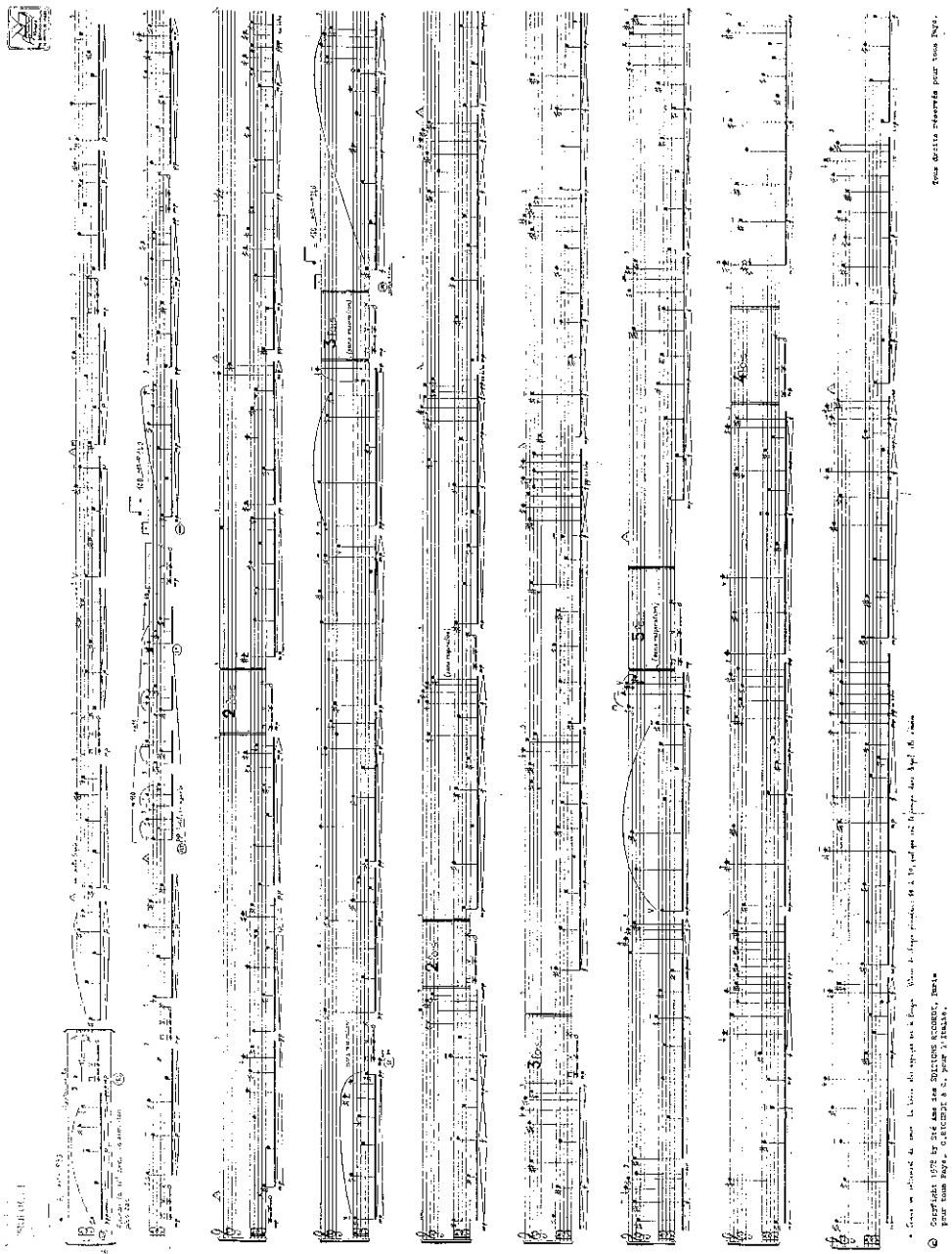


Figure 2 From *Prologue* for solo viola (p. 1). © G. Ricordi & Co., Milan.

> In this connection I would mention Mozart, who with his unfailing psychological insight portrays in *Die Entführung aus dem Serail* a character at the height of a neurotic delirium: Osmin
>
> see Aria No 19: "und die Hälse schnüren zu, schnüren zu, schnüren, schnüren, schnüren . . ."
>
> The musical discourse is literally halted: the sounds twist and turn indefinitely, caught in the trap of an obsession.

In serial music, rhythmic or harmonic periodicity, having been dispensed with, is made infinitely haunting by its very absence. The octave, another form of periodicity, was disturbing to the point where one could dream of non-octaviated spaces (Wychnegradsky, Varèse, Boulez). To the contrary, repetitive (or minimal) music in some way embodied the "return of the repressed object". This type of periodicity, similar to those found in numerous African musics, seeks a state of trance by annihilating time. We shall see later on how this hypnosis works.

Neither of the above stages applies to us. Periodicity is irreplaceable; it allows a pause in the music's unfolding, the suspension of time and, sometimes, a redundancy helpful to our powers of comprehension. When the musical structure demands it, we use it for its intrinsic qualities, avoiding both rejection and obsession.[3]

b) *Continuous-dynamic*

1) For the perception of durations, logarithmic curves certainly have an importance equal to the harmonic spectra which determine the timbre of a pitch. The perception of the durations is actually governed by the same law as that of pitches and intensity: the law of Weber/Fechner, which may be roughly expressed as:

$$S = k \log E$$

Where S is the sensation (or the psychological dimension), E is the excitation (or the physical dimension) and k is a constant value which conditions the relationship between an augmentation of S and a given augmentation of E

Sensation therefore varies roughly as the logarithm of excitation.

As every musician has been able to see for himself, to maintain an equivalent sensation of difference whatever the duration, one must have a longer difference between long durations than between short durations. In addition, the spontaneous acceleration of a musician is always of the logarithmic type.

2) To make the transition from periodicity (cf. Fig. 3) to acceleration or deceleration, it is only necessary to add or substract a factor to a given duration (arithmetic progression of the first, second order, etc; cf. Fig. 4) or to multiply or divide this duration by a factor (geometric progression; cf. Fig. 5).

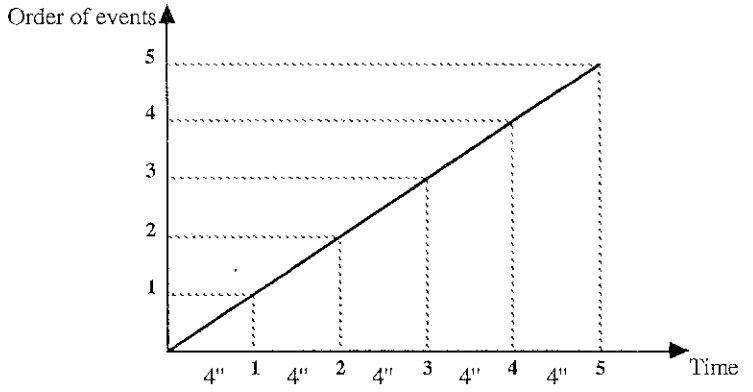


Figure 3 Periodic durations.

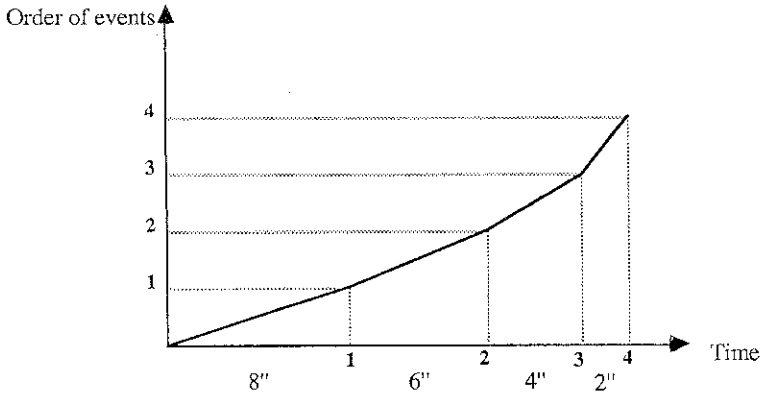


Figure 4 Arithmetical progression.

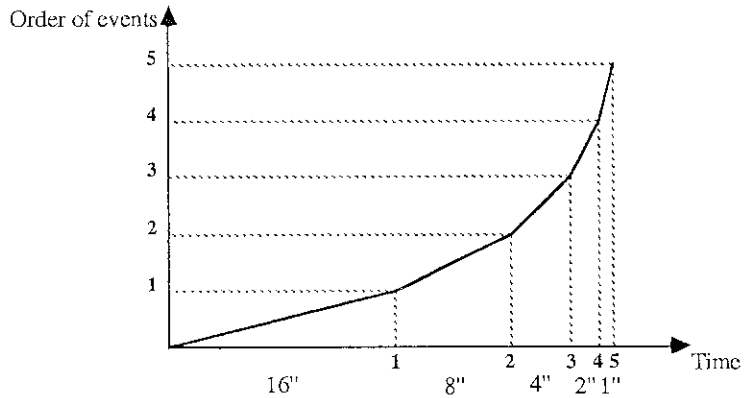


Figure 5 Geometric progression.

In order to visualize these accelerations and decelerations, we represent on the ordinate the order of events and on the abscissa the projection of these events in the temporal axis.

These "curves" bring a great flexibility to the temporal distribution of sounds whilst controlling *the degree of tension and the speed of the processes*.

Replacing the order of events by the order of the frequency components and the time axis by a linear frequency axis, these curves may well be made to correspond, in the realm of timbre, to spectra with different degrees of harmonicity. (Such inharmonic spectra are produced by certain instruments – the piano, for example – but can also be produced electronically by methods such as frequency modulation).

It is these progressions which orientate the evolution of the sound positively or negatively, which from then on is no longer static and neutral but *dynamic and charged with directed meaning*.

3) Psychologically the acceleration of durations reinforces the progressive blurring or fading of sounds that takes place in our memory: the longest events memorized are also the earliest. Through acceleration, the present is made more dense, the arrow of time at full speed, and the *listener is literally propelled* towards something which he does not yet know. The arrow of his own biological time and that of musical time, added together, cause a complete loss of memory.

By contrast, the deceleration of durations contradicts the fading of sounds: the shortest events memorized are the earliest. A slowing down induces a sort of expectancy in the void of the present. Here it functions as a rebalancing of forgetfulness, the most salient densities being the earliest. With deceleration, *the listener is pulled backwards*, since the arrow of musical time had somehow turned in the opposite direction. But because our listener also perceives that the arrow of his own biological time had not changed course, he will oscillate indefinitely between these two senses of time going in opposite but concomitant directions, in a sort of state of *temporal suspension*.

Our mind rapidly tires of this game. As with "infinite" acceleration where differences end up confused in the window of the present, our perception no longer being sufficient, durations that are too long and too slow to come no longer allow a comparison of the sounds with one another, and fatigue our waiting.

In this connection we may refer to the marvellous film by Werner Herzog, "Aguirre". The temporal structure of the film seems to be based on a continuous slowing down, the events becoming fewer and further apart until the end, even as the tension of the viewer grows. This film should also be seen for its evolutionary structure (density of events, behavior of the principal characters, photography, lighting, etc.)

Empirically we have observed that we tolerate a long acceleration followed by a short deceleration rather than its opposite (a short acceleration followed by a long deceleration). Why?

Is it a matter of a form that relates to us physiologically? Or perhaps it is precisely this double sense of time and the void of expectation, in which the rarefaction of events keeps us suspended, that we can only tolerate for a limited time, whilst by contrast the vertigo induced by acceleration makes us forget chronometric duration?

To conclude, let us remember that acceleration and deceleration, just like periodicity, form part of our daily experience: cardiac and respiratory rhythms which determine the different phases of sleep subject us to those phenomena every night.

On the other hand, a new science, chronobiology, is in the process of revealing a series of temporal images of man correlative to the purely spatial anatomical image. It is certain that musicians will have much to learn about these multiple periodicities: daily, diurnal, nocturnal, monthly or annually, as well as their synchronization.

Question: Where is the threshold of perception between periodicity on the one hand and acceleration or deceleration on the other? In other words, what is the shortest perceptible acceleration or deceleration?[4]

c) *Discontinuous-dynamic*

To avoid too great a predictability – something for which one might occasionally criticize logarithmic curves – two types of acceleration and deceleration remain for which an equivalence can be found in filtered spectra (suppression of certain areas of harmonics) and in spectra composed of completely inharmonic, and therefore unpredictable, partials (bells and gongs, for example).

1) Accelerations and decelerations by step which skip entire sections of the curve in order to immediately introduce the state of a sound as it was to be at a later moment (Fig. 7).

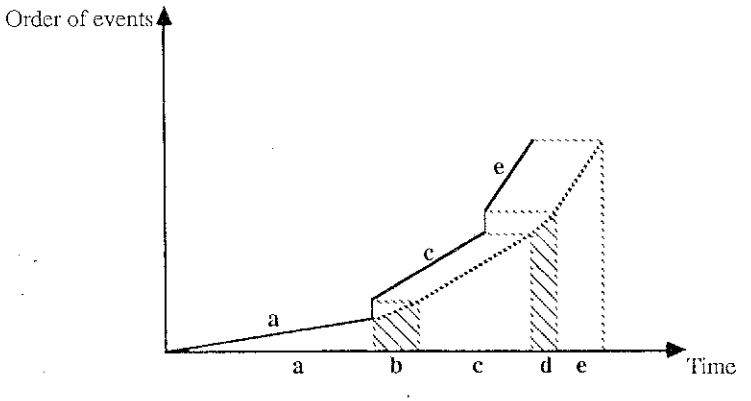


Figure 7 Acceleration by elision.

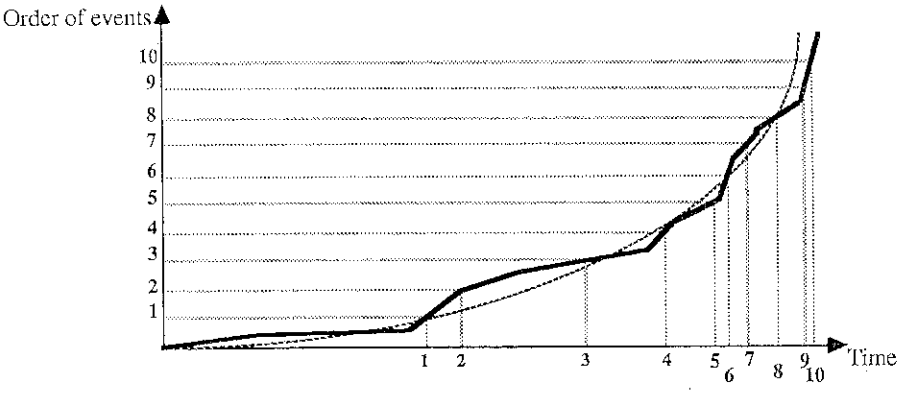


Figure 8 Statistical acceleration.

Such a phenomenon would be perceived either as a simple discontinuity, or in the best of cases as a compression of the acceleration process, the listener re-establishing the formal link which exists between a, c, e in Fig. 7.

2) Statistical accelerations and decelerations which proceed from a positively or negatively oriented discontinuity (Fig. 8).

The Gestalt of a temporal sequence thus determined remains orientated vectorially whatever the statistical meanderings. Excluded from the global form, pure chance is thus limited, held back in some way; the general dynamism takes over. It does not follow, however, that our perception is automatically able to work out the orientation of such a sequence. If the curve is too long, or if the ambitus of the differences in durations or in rhythmic densities is too large, we will pay greater attention to the surprise of the moment than to the actual sense of the sequence. Excessive discontinuity and excessive information focus our attention on the present moment, prevent us from taking any kind of retrospective view, and put a mute in our memory!

Of course, all types of superimposition of different curves come into the category that we have just defined. However, it is no longer so much a matter of imagining different curves as in the preceding category, than of composing with continuity and discontinuity, with dynamism and stasis, an unstable and perpetually renewal play. Here we encounter the principle of uncertainty in perception: *what we gain in dynamism we lose in unpredictability, and vice versa.*

Questions:
1) What specific relationships must the sound contents *a* and *c* (Fig. 7) have so that *a* and *c* are perceived, not as a simple discontinuity but as an *elision*, a compression of *a–b–c* into *a–c*? Such faults exist in geology which permit the immediate reconstruction of the continuity of opposing strata.

2) Find a law defining a relationship between the total duration of the sequence and the range of the statistical variations of micro-durations, as we perceive and memorize clearly the positive and negative sense of the sequence. What is the threshold at which the perception of this vector definitively gives way to the perception of the discontinuity of the present moment?[5]

d) *Statistical*

Like a veritable white noise of durations (Cf. Fig. 10) , the probabilistic distribution of a vast scale of durations leaves us no possibility of prediction. The degree of disorder is at its maximum. Absolute discontinuity will only hold our attention for an extremely limited time.

Even if it is possible to color with a little energy such a region of frequency of white noise, *it must be possible within this absolute discontinuity to organize "islets" of continuity.*

e) *Smooth*

To this picture we can add (non)-rhythm, seamlessness or lack of all temporal division. This "seamlessness", this absence of durations can

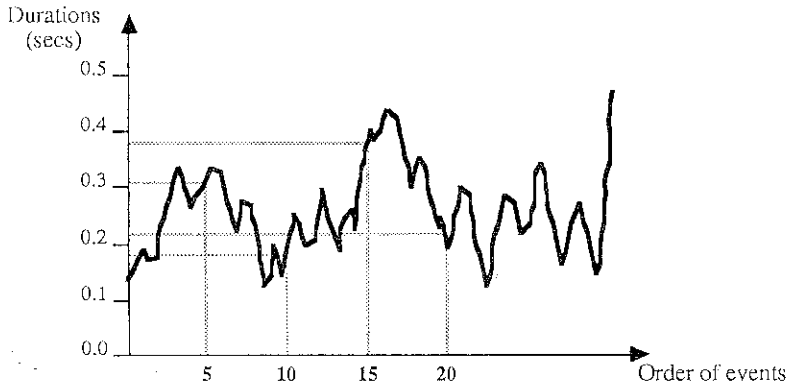


Figure 10 "White noise" of durations. The reading of durations for events numbered 5, 10, 15 and 20 are approximately 0.31, 0.18, 0.38 and 0.22 seconds, respectively.

either be entirely perceptible, the rhythms being only operative, or can be perceptible *and* conceptual, a rare case of the total absence of any event, single sound or rhythmic silence.

Question: From what threshold is a duration no longer appreciated as such – which would make it unfit for rhythmic combination?

Conclusion

The categories that we have just defined do not have to be limiting. Like musical parameters, they are only a reference for the reader, a sort of axiom which permits us to tackle the problem of durations. We can sense that between these categories there are other classifications possible among which we will discover new ones, and so on, indefinitely. We have, on the other hand, voluntarily left aside all combinatory systems realized by the composer, which defy all classification. Such a schema is never affixed exactly to musical reality, which is infinitely more complex.

To more closely approach this musical reality, we will pass on to the "flesh of time" where sounds, like living cells, will come to inhabit and envelop the temporal skeleton with their density and complexity.

To close this chapter on temporal structures I am tempted to paraphrase St. Just ("Revolution must stop at the perfection of happiness!") by saying that *structure*, whatever its complexity, *must stop at the perceptibility of the message.*

The flesh of time

Definition

Having tried to classify the quantitative aspect of musical time in order of complexity, here are some guidelines for a more qualitative approach: what I call the flesh of time.

It is certainly the case that I have often advanced explorations in the direction of this present section. In fact it seemed to me virtually impossible to reflect on structures of musical time without immediately touching on phenomenological and psychological aspects.

The flesh of time is the unacknowledged part of musical composition. It is thus that we understand such phrases as:

"The rest is up to the musicians!"
"This can't be learned."
or perhaps "It's a matter of intuition."

However, if we believe blindly in the intuition of the musicians, we believe equally blindly that this can be developed as patiently as the art of good reason. Subtler and more nebulous than the preceding section, it is here a question of approaching the immediate perception of time in

its relationships with the sound material. The same temporal skeleton may be enveloped and therefore perceived differently according to the way in which the volumes and weights of the musical flesh are distributed. To a greater extent than for the skeleton of time, we will be attentive here to the relativity of any temporal structure from the moment a sound materializes it.

Degree of preaudibility

By including not only the sound but, moreover, the differences perceived *between* sounds, the real material of the composer becomes the degree of predictability, or better, the degree of "preaudibility". So, to influence the degree of preaudibility we come back to composing musical time directly – that is to say perceptible time, as opposed to chronometric time.

> Karlheinz Stockhausen had already anticipated the importance of this by using for certain works (*Carré* for four orchestras and four choirs, 1971) what he called the degree of change (*Veränderungsgrad*) (1963, 1967, 1971, 1978). This notion is itself the direct outcome of information theory.

I believe that the composer who wants to give time a musical value must focus on this point. It is no longer the single sound whose density will embody time, but rather the difference or lack of difference between one sound and its neighbor; in other words, the transition from the known to the unknown and the amount of information that each sound event introduces. In his composition class Olivier Messiaen said that it was necessary to have at least two sounds, or a silence and a sound, in order that there be music!

V. Nabokov wrote on this subject: "Maybe the only thing that hints at a sense of Time is rhythm; not the recurrent beats of the rhythm but the gaps between two such beats, the gray gap between black beats: The Tender Interval . . . ." (1969).

This brings us back to "composing around space", rather like sculptors (cf. Henry Moore) whose hollows are not holes bored into the material, but forms in negative around which the volumes are articulated.

Let us imagine a sound event, *A*, followed by another event, *B*. Between *A* and *B* exists what one calls the density of the present, a density which is not a constant but which expands and contracts according to the event. In effect, of the difference between *A* and *B* is virtually nil, in other words if the sound *B* is entirely predictable, time seems to move at a certain speed. By contrast, if the sound *B* is radically different, and virtually unpredictable, time unfolds at a different speed.

There must exist holes in time, analogous to what aeroplane passengers call "air pockets". Chronometric time is never obliterated,

but our perception of it can overshadow the linear aspect for a more or less brief instant.

Thus, for example, an unexpected acoustic jolt causes us to skate over a portion of time. Sounds perceived during the ensuing moment of readjustment – a moment which is necessary for us to regain a relative equilibrium – no longer have anything like the same emotional or temporal value. This jolt which disturbs the linear unfolding of time and which leaves a violent impression in our memories, makes us less likely to grasp the shape of the musical discourse. *Time has contracted.*

On the other hand, a series of extremely predictable sound events gives us ample allowance for perception. The slightest event acquires an importance. Here, *time has expanded.* It is moreover this sort of predictability – this expansion of time – which we need to perceive the *microphonic* structure of sound. Everything happens as if the effect of a zoom lens, which brings us closer to the internal structure of sounds, was only able to function by way of an opposite effect in relation to time. The more we expand our auditory acuity to perceive the *microphonic* world, the more we draw in our temporal acuity, to the point of needing fairly long durations.

A law of perception therefore comes into play which could be formulated thus: *the acuity of auditory perception is inversely proportional to that of temporal perception.*

This can also be explained by a simple transfer of energy. It is known, for example, that the energy consumed by visual perception (film, TV) is such that in order to have a satisfactory auditory sensation we must increase the sound level (Grisey, 1978).

> This brings us closer to applications of the principle of uncertainty formulated by quantum physics which here is "a principle of limitation of information receivable from the outside world" (Moles, 1966).

Duration and microphony

As a result of the extreme expansion of time, we arrive at the very heart of sound whose material is revealed by the effect of an inordinate magnification.

What remains of the dynamism of global structures when, with our ears riveted to the *internal* dynamism of sounds like the eye to a microscope, we become deaf to every *macrophonic* event, or more precisely to all forms of relationships linking these events: melody, harmony, articulation, rhythmic gesture etc . . ., in short, all that traditional Western music proposes?

Let us imagine ourselves, like the hero of C. Castaneda's work (1975) contemplating the water at the edge of the river, then progressively, mentally reduced to the size of the molecules of water until we ourselves become molecules; we would certainly be surrounded by an unheard of

landscape, but would we still feel the force which sweeps these molecules of water out to sea?

The relativity of perception suggests that, for the perceiver, there must be a halt in the traditional musical discourse, a point of suspension.

One can find numerous examples of these suspensions in traditional music. To mention only a few:

W. A. Mozart, Symphony No 40 in G minor (K 550)
1st movement: bars 58–62 then 241–245
J. Brahms, Piano Concerto No 2 in B flat major (op 83)
1st movement: bars 238–244, then 245–260
A. Bruckner, Symphony No 9
1st movement: bars 539–549
3rd movement: bars 21–29, then 121–129
R. Wagner, Das Rheingold
Prelude

What continues to attract me is the possibility in the future of imagining *structures which are no longer fixed to a single type of perception*. Temporal structures themselves acquire a plasticity relative to the change in scale. *These scales of sound proximity* – for which one can always substitute a continuum – create a new dimension of sound: depth, or the degree of proximity.

Moreover, this play of the zoom lens back and forth can in turn become structural and generate a new dynamic of sound forces relative to the spatial density of sounds and their duration.

> If one wanted to find an equivalence in electronic music one would have to mention reverberation, but with all the caution necessary for so simplistic an analogy, since the control that the composer of instrumental music maintains over this field of depth is not commensurate with a potentiometer; it can act not only on the spectral content but on the time of the phenomenon. Digital reverberation, in a more complex way, perhaps brings us a more detailed control of these phenomena.[6]

Object and process

From now on it is impossible to think of sounds as defined objects which are mutually interchangeable. They strike me rather as force fields given direction in time. These *forces* – I purposely use this word and not the word *form* – are infinitely mobile and fluctuating; they are alive like cells, with a birth, life and death, and above all tend towards a continual transformation of their own energy. There exists no sound which is static, immobile, any more than the rock strata of mountains are immobile.

By definition, we will say that sound is transitory. It is not defined by an isolated moment, nor by a series of isolated moments fastidiously realized and placed in sequence.

What would bring us to a better definition of sound would be the knowledge of the energy which inhabits it and of the network of correlations which govern all its parameters. One can imagine an ecology of sound, like a new science placed at the disposal of musicians . . . (Grisey, 1978).

Since sound is transitory, let us go further and say: *object and process are analogous. The sound object is only a process which has been contracted, the process nothing more than an dilated sound object.* Time is like the air that these two living organisms breathe at different altitudes. It is the scale which creates the phenomenon and the difference resides in our faculties of perception. The process makes perceptible what the rapidity of the object hides from us: its internal dynamism.

The object allows us to understand the process in its Gestalt and to effect a system of combinations.

> Questions:
> 1) To what point can one compress an instrumental or electronic process without its becoming an object?
> 2) What is the maximum compression that a process of "instrumental synthesis" can carry without its falling back into the discontinuity of instrumental transients?[7]

The composition of sound objects refers to instrumental gesture. At its most violent it remains human because it is never very far from language. It affirms the individual and the singularity of his voice.

The composition of process springs from everyday gestures and, even by that, frightens us. It is inhuman, cosmic and provokes a fascination with the Sacred and the Unknown, reaching out to what Gilles Deleuze defined as the splendour of *ON*:[8] a world of impersonal individuations and pre-individual singularities (Deleuze, 1986).

> Digression: The art of music is a violent art par excellence. It gives us to be perceived what Proust called "a little time in a pure state", this time which supposes both the existence and annihilation of all forms of life.
>
> Music, impregnated by time, is invested with this violence of the sacred of which G. Bataille (1986) speaks; a violence silent and without language, that only sound and its becoming can possibly, and only for an instant, evoke and exorcise.

The skin of time

Definition

We left the areas where the composer's action still remained effective (the skeleton of time) to arrive, gradually, at the point where his action

was becoming more circumspect, more cautious (the flesh of time). This section touches mainly on the areas of investigation by psycho-acousticians and sociologists. How does the listener organize and structure the complexity of a sound? How does his memory choose what he perceives? What roles do his culture and musical education play in this choice? In what time does this listener live and breathe? So many questions which I will not try to answer here, since they seem to me to belong more to the sociologist's or psychologist's area of research than to the empirical reflections of a composer.

With the skin of time, we enter a field where the composer notices more than he acts. The skin of time, a place of communication between musical time and the listener's time, is not very open to his interference.

Memory and erosion

We can imagine degrees of presence of sound leading us progressively from the present (minimum period of perception, constant of time) to the very width of the present to which one's immediate memory adheres – "a sort of phosphorescence of immediate perceptions" (Moles, 1966) – then, ultimately, to the more or less immediate past where what we rightly call the memory – sometimes called cognitive memory – operates.

Likewise, it seems that one can distinguish two approaches in the manner of composing and perceiving time, one favoring the moment and the immediate memory of the sound event, the other placing great trust in the cognitive memory of the listener which, we might say, would be in a position to gather, compare and hierarchically organize the elements of a musical discourse spread out over a very long period of time.

Let there be no mistake about it! Both approaches can be structural, but in the first case the whole – the large-scale form – is an emanation, an enlargement of the moment, whilst in the second the whole is formulated a priori, the moment only keeping the attention as a consequence of the whole. It does not follow that perception automatically follows the intention of the composer in one or the other mode of thinking and composing his music.

Apparently, then, we are faced with a sort of temporal perspective moving from the present to the past which progressively degrades sounds, those furthest away in time being the most indistinct in our memory.

Nothing is more simplistic than such a conception, however. We ourselves are beings in the process of evolution, in continual movement, and our perception makes choices at each moment from a mass of information. On the other hand, let us not forget that our perception of time is sometimes the opposite of how we remember it: in a busy day time can seem to pass quickly as we experience it, but on recalling the day we say "what an interminable day!" Similarly, to a quiet day

corresponds the perception of time passing slowly and the memory of a day soon over.

To counterbalance the effect of entropy, this permanent distortion of sound in our cognitive memory, the composer has very few means at his disposal. Here are some of them:

(a) The repetition of an event helps and sometimes forces it to be memorized (cf. what has been said on periodicity).
(b) The degree of salience of a sound or a sequence can help it to be memorized. A violent, unexpected sound, for example, can leave a lasting trace. This is the very purpose of contrasts.
(c) To the contrary, in the composition of certain types of processes, the diffence between one event and the next is virtually nil (the degree of pre-audibility tends towards infinity).

At its most extreme, if this continuity is maintained throughout the duration of a work, it is virtually impossible to memorize anything. With no prominent event making an impact on our consciousness, the memory slips. It has nothing to latch on to – hence the effect of intense fascination or hypnosis – and all that emerges is a hazy memory of the contours of the sound's evolution. Time past is no longer measurable: I would call this process psychotropic, or better still chronotropic.

(d) The point of juncture between ordinary time and musical time is particularly salient. The beginning and end of a piece are strategic points in our memory.[9]

Insight

To the complex time of a piece of music – a veritable web of correlations subjected to all the deformations enumerated in this article – we must finally relate another aspect of time, infinitely more complex: that of the person who perceives.

It is in fact the listener who selects, who creates the changing angle of perception which will endlessly remodel, perfect, sometimes destroy musical form as the composer dreamed it. In turn, the listener's sense of time is in correlation with the multiple times of his native language, social group, culture and civilization.

In closing, we arrive at the limit of the powers of this little demi-god which the composer, consciously or not, still believes himself to be: the Other. Inaccessible, unimaginable, the other, the ideal listener only exists like the utopia which allows us to create in the face of and in spite of everything.

Here our role comes to an end: we will never know exactly the capacities of perception, the culture, receptivity and psycho-physiological state of this ideal listener.

If and when it takes place, music – and with it the artificial time that gives it life – envelops us like a kind of amniotic liquid. With nothing to

muffle our ears, we remain open and receptive. Violent once more, it induces ecstasy or repulsion, or in the worst case indifference.

What will be inscribed on our memory will be precisely these corridors, these transmissions, these coincidences which sometimes establish themselves between our sense of time and that of the composition.

These transfigured moments of time fulfil us to the point of ecstasy since they are, at a given moment, exactly the fulfilment that our "emptiness" requires, or the vertiginous vacuum to which our body, saturated with physiological rhythms, would aspire.

These shocks, these impacts, because of the affect they provoke, will illuminate certain sound events and render then *unforgettable in their own right*. We will then have regained entropy a little, and in our own way.

"The last word", Varèse said, "is imagination!"

To this I would add emotion which, ultimately, creates musical form as it is perceived.

"Music is number and drama", said Pythagoras.

Real musical time is only a place of exchange and coincidence between an infinite number of different times.

Acknowledgements

The musical examples taken from the scores of *Dérives* (Figs. 9, 13), *Modulations* (Fig. 11), *Partiels* (Fig. 6), *Prologue* (Fig. 2), *Tempus ex Machina* (Fig. 1) and *Transitoires* (Fig. 12) are reproduced with the kind permission of G. Ricordi & Co., Milan.

Translated by S. Welbourn

Notes

1. This short essay, written in 1980 for a course at the 'Internationale Ferienkursen' in Darmstadt, was revised in 1985 for the present publication. My musical experience and practice are such that I would now tend to consider certain declarations as too peremptory. It is true that what was easy to state forcefully and categorically some years ago has subsequently become an integrating part of the thought and technique of an increasing number of composers and theorists.
2. For a more in-depth analysis, see rehearsal Nos. 1–10 of the score *Tempus ex Machina*. (cf. Fig. 1)
3. A musical analysis of the first pages of *Partiels* for 16 or 18 musicians or of *Prologue* for solo viola will illustrate my use of periodicity as both a weight and as a reference point. (cf. Fig. 2)
4. Here I suggest the analysis of the temporal structure of *Jour contre Jour* for 14 musicians and magnetic tape as well as Nos. 28–31 of *Partiels*. (cf. Fig. 6)
5. Listening to and eventually analyzing *Dérive* for two orchestral groups from No. 10–22 of the score, as well as *Partiels* from No. 24–41 would provide a perfect illustration of the discontinuous-dynamic which is mentioned in this chapter. (cf. Fig. 9)
6. For a better understanding of what I mean by the scale of proximity, listen to and analyze the large-scale polyphony of *Modulations* for 33 musicians from No. 31–45 of the score, or to the beginning of *Transitoires* for 84 musicians from No. 18–43. (cf. Figs. 11 and 12)
7. In *Tempus ex Machina* compare the sound objects at Nos. 1 and 2 of the score to the process used from No. 40 to the end of the piece. (cf. Grisey unpublished)
8. *ON* in French is the third person singular neutre pronoun, translated as *one* in English, e.g. *one* goes to the concert hall.
9. Four examples of transition from an ordinary tempo to musical tempo:
   Dérives from the beginning to No. 2. (cf. Fig. 13)
   Partiels from No. 49 to the end.
   Sortie vers la Lumière du Jour from the beginning to No. 2.
   Jour contre Jour from No. 37 to the end.

References

G. Bataille, *Erotism: Death and Sensuality* (City lights Press, San Francisco, 1986, trans. M. Halwood).
P. Boulez, *Notes of an Apprenticeship* (American Biographical Services, reprint from 1968 edition).
P. Boulez, *Boulez on Music Today* (Faber & Faber, London, 1971, trans. S. Bradshaw & R. R. Bennett).
C. Castaneda, *Tales of Power* (Touchstone Books, 1975).
G. Deleuze, *Différence et répétition* (Presses Universitaires de France, Paris, 1986).
G. Grisey, *Périodes* (Ricordi, Milan, 1974; with preliminary text).
G.Grisey, *Dérives* for 2 orchestral groups (Ricordi, Milan, 1974).
G. Grisey, *Partiels* for 16 or 18 musicians (Ricordi, Milan, 1976).
G. Grisey, *Modulation* for 33 musicians (Ricordi, Milan, 1978).
G. Grisey, *Prologue* for solo viola (Ricordi, Milan, 1978).
G. Grisey, *Sortie vers la Lumière du Jour* (Ricordi, Milan, 1978).
G. Grisey, Zur Entstehung des Klanges, *Darmstädter Beiträge zur Neuen Musik* (1978).
G. Grisey, *Jour Contre Jour* for 14 musicians (Ricordi, Milan, 1980).
G. Grisey, *Tempus ex Machina* for 6 percussionists (Ricordi, Milan, 1981).
G. Grisey, *Transitoires* for 84 musicians (Ricordi, Milan, 1982).
G. Grisey, A propos de la synthèse instrumentale, unpublished manuscript.
G. Ligeti, *Lontano* for orchestra (Schott, Mainz, 1969).
O. Messiaen *The Technique of My Musical Language* (American Biographical Services, reprinted from the 1956 edition).
A. Moles, *Information Theory and Esthetic Perception* (Univ. of Illinois, Urbana, 1966, trans J. E. Cohen).
V. Nabokov, *Ada* (Pengiun Books, New York, 1969).
K. Stockhausen, *Texte 1–4* (Dumont Dokumente, Köln, 1963, 1964, 1971, 1978).
K. Stockhausen, *Gruppen* for 3 orchestras (Universal Editions, Vienna, 1963).
K. Stockhausen, *Stimmung* for 6 vocalists (Universal Editions, Vienna, 1969).
K. Stockhausen, *Carré* for 4 orchestras and 4 choirs (Universal Editions, Vienna, 1971).
I. Stravinsky, *Poetics of Music* (Harvard University Press, Cambridge, Mass., 1942).