Composing within sound
(An Introduction)

This paper deals with the compositional approach used in two of my compositions: Interro (Notes of relation in a system of sound) and From the Corner of a Cloud. It has been made possible exclusively through the use of computer, and its purpose has been to organize sound material on the basis of an organic set of interdependent parameters, whose inter-relations govern both their various values, and their articulation within the compositional design. In particular, that which I designate "System of sound" has the twofold property of being both structured and structuring, since it regulates both the formation of sound material in its space-time projections and the containment of that range of projections within the system. The definition of the boundaries of a system of sound is obviously part of the creative process, inasmuch as, following this methodology, the composition is already virtually present in the system. Because both the sound material and the compositional form, the boundaries for which are established by the composer himself, are generated from the same system, the composition will therefore be a reflection of the composer's inventive powers on all levels.

Thinking in ratios

Music has always been made of intervals, not of notes. Thinking in terms of ratios is fundamental in establishing and articulating all the parameters which make up a "system of sound". A ratio is a symbol that not only represents the division between two terms, but at the same time indicates a distance or interval. For example, 3/2 is 3 divided by 2, which equals 1.5; and it is also the interval between 10 and 10, or between 500 and 400. In the definition of a
ratio the values of the two terms can vary, but the interval remains the same. In this way it is possible to project a series of intervals into different frequency regions, maintaining the same ratios but obtaining different frequency values. In Interpre and From the Corner of a Cloud all the values that make up the basic series of ratios are generated by the combination of the factors 2, 3, 5, and some of their multiples, obtaining in this way a total of 53 harmonic ratios within the 2/1 ratio.

My own use of this basic series has been made in the full awareness of the fact that this does not represent the only possible subdivision of an octave capable of providing musical interest. It is my conviction that the principle characteristic of any musical system is furnished more by the exact definition of the ratios vis à vis the system of which they are part, than by the internal structure of the system itself. In any case, it is important to note that this system of intervals has deep roots in the history of musical theory and that it contains all the fundamental intervals found in any musical tradition. Generally we tend to identify ratios with pitch, but in fact thinking in ratios can be extended to include any musical parameter, be it amplitude, duration or formal element. This consideration is particularly true of frequency and duration. Indeed there is no substantial difference between these two parameters inasmuch as they both belong to the domain of time; they are simply situated in different regions of a continuous scale of ratios. Durations are thus formed in the continuation downwards of frequency divisions (Example 1), or by going beyond the ratio 2/1 (Example 2). Obviously it is not necessary to use all 53 ratios in the composition of a

(1) Harmonic ratios are held to be only those ratios whose constituent terms can be reduced to 1 when divided by 2, 3 and 5.
system of sound; only those are chosen which are pertinent to the 
particular type of compositional requirement. These ratios regulate 
the frequency, amplitude and duration of both the single elements 
and the formal ones.

Formation of mixtures and their characteristics
A "system of sound" can be made up of one or more mixtures. A mixture 
is formed of 2 to x sinusoidal component related to each other 
according to the arrangement of intervals chosen to characterize 
the desired "system of sound". The single sinusoidal component as 
well as the mixtures can be articulated independently of one another 
in time. The characteristic of a mixture is determined by texture, 
category and level of tension of the intervals employed. (Texture 
depends on the disposition of intervals within the mixture, and thus 
the texture of a mixture can be more or less tightly woven according 
to how the intervals are distributed in the frequency space. This 
principle is illustrated in the contrast between the arrangement of 
intervals (1) in Example 3 and that in Example 4. In the first mixture 
the frequencies aggregate is loosely woven, and eight components 
cover with a fairly even distribution a space that ranges from 100 
 to 167.5 Hz. The second mixture is more tightly woven, since the same 
number of components cover a space ranging only from 100 to 125 Hz. 
If this principle is applied one can obtain widely differing textures, 
as in Example 5, where there are a number of zones of interval 
concentration. The two zones of the mixture, as is clearly seen, are 
contained between 117.1 and 126.6 Hz, and between 160 and 177.8 Hz. 
The category of an interval depends on its factor class. In order 
to understand what is meant by factor class we must return to the 
concept of ratio. The two terms that form a ratio differ essentially 
(1) In all the examples the development of ratios is done at 1 = 100 Hz.

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in that the denominator represents a basic division, while the numerator represents the quantity of elements contained in this division. This can be seen in the example of a vibrating string, as in Example 6. Since the vibrating part of a string is inversely proportional to the frequency, half way along the string (1/2) the frequency is double (2/1), while 2/3 along the string the frequency is 3/2 higher, and so forth. With a given generating frequency (1/1) it is possible to obtain one or more series of frequencies that go upwards or downwards simply by respectively multiplying or dividing the generating frequency by one or more given ratio, as in Example 7. When we then carry these intervals over the octave (2/1), 2/3 (a fifth downwards) = 4/3 (a fourth); and, according to where the factors 2, 3, 5 are located and their numerator and denominator power, categories of intervals which are homogeneous in terms of factor class can be formed, as in Example 8. The role played by interval categories within one or more mixtures is that of establishing different gradations of color.

Another element which characterizes the formation of mixtures is the level of tension deriving from the relation among intervals. In principle this element can be obtained by working with the natural tendency of complex intervals to be attracted to more simple ones (i.e. those formed by a small number), which quite literally act as poles of attraction, or resolution, vis-à-vis all other intervals. In our field of action the levels of tension are connected both to the categories of intervals and to their reciprocal relations. In other words, within a mixture levels of tension can be created between intervals of a single category, and at the same time by the counterposition of a number of categories. In Example 9, within a constellation of intervals of the same category, a level of global tension is created which rotates around the interval 3/2. This interval, besides acting as a pole of attraction, is also the factor class which generates the other intervals: 81 = 3⁴ and 243 = 3⁵.
A different level of tension is created when two constellations of intervals, each with its own hierarchical order or pole of attraction, coexist in the same mixture, as in Example 10. In this case the level of tension arises from the ratio between the intervals that form the two constellations, as well as from the attraction of the constellation 5/4 to the constellation 3/2. The interval 5/4 can become in turn the pole of attraction for the entire mixture, altering the interval 3/2 into something more complex, such as 27/16 = 1 3/4. Thus, the opposite situation is created, as represented in Example 11. In a procedure of this type one need only change the value of a single ratio to give the mixture a completely different character. Naturally the greater the number of poles of attraction, the greater the tension among the intervals.

Configuration and space-frequency projection of mixtures

As we have seen, a mixture is achieved by multiplying or dividing a frequency chosen as the generator of the mixture by the ratios which constitute it. In this way one passes from a series of ratios to the corresponding series expressed in Hz derived from these ratios. A mixture, moreover, can be projected into different frequency regions, thus defining a frequency matrix generated by a single frequency (Examples 12 and 13). A matrix formed by 64 sinusoidal components divided into eight mixtures of eight components each is used to exemplify this principle. But obviously matrices of any dimension may be constructed.

A mixture is projected into a frequency space in two fundamental ways. The first is obtained by multiplying or dividing the frequency resulting from each ratio of the projection successively by all the ratios of the configuration of the mixture. In this way the same configuration is projected into different regions of the frequency space (Example 14). The second is obtained by multiplying or dividing the frequency resulting from each ratio of the
projection successively by all the ratios of each configuration of the mixtures so that the configuration of each mixture is always changing and is projected into different space-frequency regions (Example 15). Quite clearly it is possible to obtain a whole series of variants in these two ways. One criteria I have often used in the course of the composition of my works consists of holding the frequency limits of each mixture constant, and varying only their internal configuration (Example 16). All the ratios can furthermore be projected towards high or low frequency regions by multiplying or dividing each by the factors 2, 3, 5 and their multiples, as in Example 17. With a similar procedure the expansion and contraction of both the configuration of the mixtures and their projection can be obtained. As we have seen this technique is also applied to duration.

Internal motion of mixtures

Obviously we will not deal with the motion of mixtures from the formal point of view of the composition, since this is tied to the invention, creativity and imagination of the composer within the limits of the system of sound he himself defines. Instead I will describe the procedure I used in establishing the frequency and dynamic movement of the single components of the mixture used in my works. This compositional method oriented towards the weaving of thickness and volume within a single sound dimension, and is primarily concerned with the mobility of each constituent part. One reason for this is that given the precision of generation and the stability characteristic of a computer, the weave of the "musical cloth" would otherwise be too perfect or "electrical", and therefore lifeless. Instead we should imagine an embroidery with all of its unevenness, down to the irregularity of the thread. In other words, it is important that each sinusoidal component in its temporal movement assumes at least a bidimensional mobility

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in frequency and in amplitude.

The most efficient methods I have found for obtaining the frequency movement of each component are two: **microglissandi** and **random frequency deviation**. In the first case each sinusoid modifies its temporal movement by varying its frequency state, carrying it in a linear or exponential way from an initial value to a higher or lower final one. But it may also return to the initial value after having reached different frequency values in a continuous manner. The steepness of the glissando is proportional to its duration, when the relation between duration and variation of frequency is carefully calibrated one does not perceive a glissando as such, but rather one has the impression of a "liveliness" in the sound. This become more noticeable when several components interact at the same time to bring about a series of beats of greater or lesser complexity. Each component follows a different trajectory (duration plus steepness and direction of the microglissando). The result is an articulated pattern of microglissandi, as can be seen in Example 18.

The second method of obtaining frequency movement is to allow the basic frequency value of each component to vary randomly. This procedure is made possible by a special algorithm and requires four parameters:

1. **Basic frequency**

2. **Lower limit**: indicates the minimum duration within which the random frequency variation must occur.

3. **Upper limit**

4. **Random deviation**: more or less with respect to the basic frequency. The deviation is expressed in cycle per second.

In order to have the uniform movement of all the components in the random deviation of frequency, one must bear in mind that a deviation (say) of 2 Hz on a frequency of 100 Hz is quite noticeable, while the same deviation on a frequency of 3 kHz is virtually irrelevant.
Therefore the range of deviation of the frequency must be considered in percentage terms in relation to the basic frequency. It is clear that both systems of frequency movement can be applied both to the single component and to the entire mixture. This is to say that in the second instance all the components of the mixture simultaneously undergo the same type of random movement.

The movement of each component even as regards amplitudes is obtained through glissandi that result from the linear or exponential interpolation in time of glissandi between different amplitude levels. The dynamic trajectory of each sinusoid can be articulated in several segments each of different duration, as in Example 19. Naturally each component in time can have a type of dynamic movement independent of the others, as in Example 20. In this example only the movements of amplitudes are seen, while the frequencies remain constant; but in practice it is important as concerns the sound texture, for each component to have its own mobility, also in frequency, even when a single series of amplitude segments constitutes the general envelope for several simultaneous components. Furthermore the global duration of each envelope, as well as of its segments, can be contracted or dilated in time in a different way according to the proportions chosen in the composition of the system of sound for the regulation of the durations.

I would like to add that this way of thinking about music is also intimately connected with my composing experience in the area of instrumental music, where I have tried to study and exploit the physical peculiarities implicit in a single sound, rather than take sound as a given or as a kind of "black box".

It is only recently that certain characteristics provided by digital electronics have offered the possibility of development of musical language on a wider basis. And here I mean characteristics such as
precision of performance and exact repeatability of a musical event, not to mention the fact that composers as generators of sound, are not themselves musical instruments. It seems to me that the study of interval relations in the world perspective of psycho-physiological nature and "expressive" relations, whether in the domain of time, or in the domain of space-frequency occupation, a central role in the perspective of a widely based development.

Finally, it seems to me to be important to confront the complex problem of musical creation today, not only from the point of view of the acquisition of music that reach us through the ear increasing refinements of electronic technology, nor certainly with reference to that type of gesture characteristic of a time and mechanical musical world, but with the conviction that the musical creation requires it own appropriate gesture. In this perspective the study of the functioning of grammatical units and their syntactic relations within the organizational and therefore communicative context of expression must in time succeed in "speaking" more that it does today.
Example 6

\( \frac{1}{2} \)

\( \frac{2}{3} \)

\( \frac{3}{4} \)

\( \frac{4}{5} \)

\( \frac{5}{6} \)
Example 6

\[ \text{3 in numerator: } \frac{7}{9} \]  
\[ \text{3 in denominator: } \frac{7}{9} \]
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Example 16