PROPORTIONALITY AND EXPANDED MUSICAL PITCH RELATIONS

BEN JOHNSTON

BEFORE CONSIDERING the problem of expanded pitch resources in contemporary composition of music, I shall contrast two different traditions for the realization of precise pitch relations in performance.

The first tradition may be represented by the practice of Gregorian chant.[1] In plainchant the melody is unaccompanied, or monophonic. Thus the relations of melodic tones to each other are the only intervals used. The perfect fifth and perfect fourth and the interval of difference between them, the major second, are the basis of pitch choice. The particular distribution of the seconds within the melodic distances of fifths and fourths, and the choice of cadence points, determine the "mode" of the music. All major seconds are always the same size,[2] as are all minor seconds, since these are the remainder intervals when the largest possible whole number of major seconds subdivides either a perfect fifth or a perfect fourth. All other intervals are likewise fixed in size, but are much more difficult to sing in tune.

A contrasting type of pitch usage is illustrated in East Indian monophonic musical practice.[3] This monophony "opposes" a line of fluctuating pitch against a fixed pitch, or drone. A specific emotional expression is achieved by means of a particular set of intervals measured against the drone. The "harmonic" relation of melodic pitches to the drone is primary to this expression, whereas the intervallic relations between melodic tones are less important. Possible relations to the drone are classified as consonant,[4] dissonant, and out-of-tune; i.e.,

[1] Cf. David Krahenbuehl and Christopher Schmidt, "On the Development of Musical Systems," *Journal of Music Theory*, Vol. 6, No. 1, pp. 32-65. This analogy presupposes the scale-tuning of medieval plainchant to have been Pythagorean, following a hypothesis independently formed, which accords with that of Krahenbuehl and Schmidt. The theoretical approach adopted in this article is fully consistent with that adopted by these authors.

[2] The 9:8 interval, the difference in size between a perfect fourth and a perfect fifth, is the Pythagorean whole tone. The size difference between two such tones and a perfect fourth (256:243) is the Pythagorean semitone.

[3] Cf. Alain Daniélou, *Traité de Musicologie Comparée*, Hermann, Paris VI, 1959, pp. 93-122.

[4] Cf. Hermann L. F. Helmholtz, *Sensations of Tone*, trans. by Alexander J. Ellis, Dover Publications, Inc., New York, 1954, pp. 182ff. The definition of consonance herein used is based upon Helmholtz's. Congruency of rates of vibration between two

not an ingredient in the conventional expression of a particular *rasa* (emotional content). There is a legitimate but subordinate use of "out-of-tuneness" in the practice of inflecting or "teasing" certain pitches microtonally. In other words, simpler intervals are deliberately distorted, for expressive reasons, into out-of-tune approximations of themselves. Viewed from the aspect of pitch alone, a performance consists of an improvised exploration of the interval content of a given set of preselected pitch relations. The number of expressively distinct interval relations used in different improvisations based upon *ragas* of widely ranging emotional expression is relatively very large. The number selected in a specific *raga*, for a particular *rasa*, is quite small.

It is immediately evident that Gregorian chant is a much simpler and also a much more restricted system of pitch order than East Indian monophony. First, the absence of a harmonic point of reference, the drone, makes the problem of singing in tune less crucial but more difficult to achieve. Even if we suppose that the final of the mode were kept in the aural imagination as a point of pitch reference, analogous to a "tonic," the monophonic idiom would preclude any very precise tuning by ear. Second, the ritual use of plainchant imposes a conscious and intentional restriction upon the emotional content of its expression.

Without any attempt to connect these examples historically, I shall contrast them to two contemporary usages of pitch which seem to be significantly analogous to them. The most obvious point of difference is that while the above examples are monophonic, the ones which follow are polyphonic. A more important difference is that the pitch vocabulary of the polyphony is significantly expanded beyond that of the corresponding monophonic examples.

Twelve-tone practice presupposes a pitch system where any octave is divisible into twelve half-steps, all of equal size. Thus all intervals which subdivide into the same number of half-steps are exactly the same size. There are, therefore, twelve different interval sizes to learn, not counting intervals expanded by the inclusion of one or more octaves. Musical usage assumes the ability to locate, given any tone, a second tone at a distance of any one of these intervals from the first tone. The twelve notes are, to quote Schoenberg, "related only to each other." Whether a linear (melodic) or a vertical (harmonic) interval is used, the method of finding the pitch is the same: to measure a known interval distance above or below another pitch in

---

tones produces reinforcement, heard as blend or consonance. Contrasting rates of vibration produce interference, which is experienced as dissonance. An out-of-tune interval is one which approximates a simpler relationship of which it is assumed to be an inaccurate version.

the context. There is not, for either performer or listener, a fixed point of pitch reference, as there is in tonal music.

As a tonic with its associated scale is analogous to a drone with its associated pitch intervals, so a piece of music without a tonic is analogous to a monophonic piece without a drone. It follows that the process of finding pitches in performing twelve-tone music is intellectually similar to that of finding pitches in plainchant.

To find the polyphonic analogy which I wish to suggest as a parallel to East Indian monophony, it will be necessary to examine some loopholes in contemporary twelve-tone musical practice and theory. For I do not propose traditional diatonic or even chromatic tonality as an alternative adequate to the expressive needs of present-day music.

In traditional triadic music the functional meaning of an interval usually determines perfectly clearly its exact tuning. But in most twelve-tone music the pitch organization obliterates this clarity. Triadic organization is usually irrelevant to such music, and there is seldom any alternative harmonic system clearly enough defined to imply unambiguous tuning. An unhappy result of this can be observed in playing such music in strict equal-tempered intonation, as, for instance, on an organ. A certain grayness results,[5] a certain lack of variety in interval color, which is observable neither in tonal music played on the same instrument, nor in the *same* music, *really well played* upon instruments capable of pitch variation in each tone. In other words, the muddy sound just mentioned can be cleared up by careful tuning *by ear*. Obviously something more than twelve fixed tones per octave is involved here. This something operates entirely outside twelve-tone organization, which deals only with twelve chromatic interval-sizes and patterns of these. More accurately, it deals in patterns made from classes of intervals. What happens when a

[5] Peter Yates has commented to me, in relation to this question, that "three organists and a pupil of Widor are among the most original composers of modern times, particularly in creating new orchestral ensembles. Bruckner, who revived just intonation in the multiple octave, Ives, Messiaen, and Varèse. . . . These composers work, organ style, by adding overtones, rather than Stravinsky style, by differentiating timbres. . . ." Yates' basic point seems to me to be the interdependence of timbre with tuning, and the dependence of both upon the balance struck in a given composition between homogeneity and "independence" of "voices" or other sound elements. While this is a valid and important point, I maintain that when the partial relationships which make up a complex tone are *harmonic* (i.e., related in pitch by simple whole-number relationships), the use of *inharmonic* intervals in the simultaneous pitch relations between fundamental pitches results in a *blurring*, the consequence of *near*-congruences of vibrations among the partials. A certain amount of inharmonicity in tones or in tuning is negligible; a little more can be interesting; too much is confusing and "sour." These boundaries shift in different musical contexts, and are always hard to delineate. A standardized uniformity in this aspect of sound is in my opinion aesthetically dull or "gray."

good string quartet, for instance, performs a non-tonal work, especially if the piece contains a large proportion of simultaneous pitch combinations, is an inflection of each pitch according to its context. Thus, in practice, there are not twelve *notes* but twelve *pitch regions* per octave. Twelve-tone organization leaves this refinement unspecified, and twelve-tone theory has no place for it.

There are two musical reasons for such refinement of pitch discrimination. One is to gain clarity and focus in the pitch relations. The other is to distort what is simple for expressive purposes. But "what is simple," in this connection, is not the *average* interval size provided by equal temperament, but the most consonant interval within the size class called for, the exact tuning determined by the pitch context. Distortion is meaningful only if the norm is clearly evident from the harmonic involvements of the interval. Its nature may even be determined by ambiguities of harmonic function. Triadic function is only one among many possible systems of harmony, though its relatively high degree of consonance makes it one of the easiest to understand by ear. Given any such system, a norm of tuning is implied, and this may be used as a foil for inflected (distorted) intervals. The two motivations for inflecting pitch are thus mutually dependent.

From this standpoint the question of consonance and dissonance, gaining a new refinement of meaning, becomes once again relevant. What Schoenberg called "the emancipation of the dissonance"[6] was actually an extension of the range of what we mean by "consonance." Dissonance still functions outside this expanded sphere of consonance. The relativity of consonance and dissonance is obsolete only if you choose to ignore it.

The need for such a tension is reflected in much post-Schoenbergian music in the contrast between tones with easily identifiable pitch, and complex timbres and noises. A complex timbre may approach noise more or less nearly. It is not difficult to establish a spectrum of timbral changes from sine tones (with only a single pitch) to white noise (with completely random fluctuation of all possible pitches). But to deal rationally with such raw materials, at least a stepped contouring of this spectrum would be necessary. And for forming musical order from relations between complex timbres

[6] I am indebted again to Peter Yates for an important clarification: "You should make a clear distinction between Schoenberg's belief that each note of the tone row is an absolute of our musical speech, without any other acoustic or key reference—therefore not to be returned in just intonation—and his subsequent practice of resuming traditional harmonic relationship or dropping it when he pleased. Slonimsky has shown that the traditional relationship is there all the time; e.g., by dropping the 'acciaccaturas' of Op. 33a."

approaching noise, as distinct from using them coloristically, it would be necessary to establish analogous relationships between pairs of such tones. The effort to achieve this kind of musical order is in its earliest stages at present. Most music which uses very complex tones extensively, relies still upon other means of ordering, such as rhythmic structure, serial ordering, and much more familiar techniques for ordering tones which have an easily perceived predominant pitch. Aleatoric and random selection are at present among the principal means for exploring unfamiliar sound materials.

If we are not to be faced eventually with the splitting apart of the art of music into an art of pitched sounds and a separate art of non-pitched sounds, we must greatly refine our understanding of pitch relationships. Such understanding must be not only theoretical (intellectual) but also practical (audible by ear in actual musical compositions). The relations between component pitches of very complex sounds include a great many with which our traditional pitch system is powerless to deal. We are, therefore, accustomed to hear, more and more, relationships which demand a more comprehensive vocabulary of pitch intervals than we now have.

Merely to multiply the number of available pitches, as with quarter-tones or any other system of temperament with more than twelve notes per octave, complicates the problem of harmonic organization without helping to solve it. Rather than to enlarge the pitch vocabulary by such artificial means, it is more desirable to expand the order we already perceive in it by means which we already understand in practice. To achieve this, two procedures are necessary. First, one must learn to tune precisely, *by ear*, a definite number of harmonic pitch relations, from which a great variety of others can be derived. For the harmonic awareness necessary to play triadic music accurately in tune (a degree of sophistication which can be generally expected), only three such intervals are needed, the octave, the perfect fifth, and the just major third. From combining and comparing these all the other common intervals used in triadic music result, and in addition many variants of these which are microtonally related to them. These same three intervals are the basis of the entire East Indian pitch system,[7] different as it is in so many ways from the modern Western musical tradition.

Secondly, one needs a grasp of the microtonal scale pattern formed by adjacent pitches which are inflections of the larger intervals of the twelve- or seven-tone scale. The seven-tone scale still forms the basis of our traditional notation system. In fact, given this diatonic

[7] Daniélou, *op.cit.*

scale tuned in consonant triads, one needs only two different pitch inflections to achieve a microtonal scale[8] the density of which can easily be proliferated to a point where the human ear can no longer discriminate between the resulting pitches. Both of these inflections result naturally from playing in tune by ear, and one of them, the chromatic half-step, is already reflected in our notational system. The other, the diatonic comma, can be represented in notation by a + (meaning raise by one comma) and a — (meaning lower by one comma).

One way of explaining how the comma results is to point out that when triadically organized music is played so as to sound at its most consonant, two different major seconds result, a larger one, which is the difference in size between a perfect fifth and a perfect fourth, and a smaller one, which is the difference in size between a perfect fourth and a just minor third. For example, if I begin on C and want to find D, the progression C, G, D and the progression C, F, D give two different D's. The comma is the difference in size between these two C, D intervals. It is about one-fifth the size of a half-step.

The inflection of the comma plays a part in traditional diatonic progressions even though it is not expressed in standard notation. Cyclic displacement by this tiny interval is a passive result of common diatonic chord patterns.[9] Similarly, cyclic displacement by a larger interval, the diesis which is approximately twice the size of the diatonic comma, results from extended chromatic modulation. This is reflected in standard notation by the use of enharmonic equivalents (e.g., the distinction between D♯ and E♭, between C and B♯, between A and B♭♭, etc.).

The use of chains of intervals of the same size is a basic principle of pitch usage. The octave, repeated cyclically in this manner, is the basic interval division of the audible pitch spectrum. The fifth, used in this way, generates the cycle of fifths. Although these two cyclic series are the most important ones, all the simple intervals are used in this way, to form what are sometimes called symmetrical chords or scales (e.g., the "chord of fourths," the augmented triad, the fully diminished seventh, the whole-tone scale, and the chromatic scale).

The most characteristic twentieth-century way of using chromatic pitch structures is in cyclic patterns, whether formed as chords, scales, successions of roots or tonics, or as twelve-tone rows (or less

[8] Ben Johnston, "Scalar Order as a Compositional Resource," PERSPECTIVES OF NEW MUSIC, Vol. 2, No. 2, pp. 56-76.

[9] Helmholtz, *op.cit.*, p. 431. The common diatonic progression I, VI, II, V, I, if common tones are kept identical and if all harmonic intervals are tuned in just intonation, will lower the pitch of the tonic by one diatonic comma.

numerous row patterns). The simplest cycles, in which only one kind of interval is used, are less common than mixed types, in which two or more different intervals alternate in regular patterns. Due especially to pitch displacement by comma and by enharmonic equivalent, many cycles appear circular. A twelve-tone row beginning with a C, for example, may actually return to B♯ or to D𝄫, or to C— or C+, or to some more complicated combination of these intervals of pitch displacement. The cyclic repetitions of row forms can be so designed as to cause pitch displacement with each successive row form. This displacement itself can be made to follow a cyclic pattern on a larger time scale than that of the row statements. To control this process, the exact size of the intervals of the row forms must be determined unambiguously by the context of notes. The pitch displacements can then be calculated, shown in the notation, and formed into cyclic patterns. Furthermore, locating pitches only by intervals which can be tuned accurately by ear, dissonant intervals which are unfamiliar representatives of interval size-classes can be made to occur in the musical texture, not only as distortions produced by melodic inflection, but also as necessary results of the harmonic process. This possibility includes many intervals smaller than half-steps, generically called "microtones."

As a performer's relative pitch discrimination becomes more acute, even intervals other than the familiar consonances become part of his expanded vocabulary of intervals. He can learn, for example, after a period of familiarization, to distinguish accurately between triadically generated intervals (particularly seconds, thirds, tritones, sixths, and sevenths) and those of the same size-classes produced by the use of "natural" seventh and eleventh intervals, such as occur in the "natural" overtone series. One does not have to look as far as ancient Greek theory or Arabic musical theory and practice to find such pitch relations. The contemporary American composer Harry Partch has been using them in his music for over thirty years.[10]

The main obstacle to learning new intervals by ear is the habit of listening only accurately enough to identify the correct size-class. For example, if precise tuning is to result, when there is an interval C, E (a just major third) in the pitch context and an A♭ enters, the performer must decide whether to tune the A♭ to the C or to the E, in which latter case it is actually a G♯, and must be pitched slightly lower than an A♭. Common usage is too careless to make such distinctions audible. In a polyphonic texture it is desirable for each

[10] Cf. Harry Partch, *Genesis of a Music*, University of Wisconsin Press, Madison, Wisconsin, 1949, Part III, *The Resources of Monophony* (pp. 109-231).

individual performer to know, at least for each harmonically functional tone, precisely to which note in the surrounding context he should adjust his pitch. Triadic music played in this way, with precise interval adjustment, gains enormously in clarity and in richness of interval color. If serial pitch organization is present, its effect is in no way vitiated by the absence of equal-tempered intervals. In fact the grayness which often characterizes twelve-tone harmony is largely eliminated. Except for keyboard and pitched percussion instruments, the needed flexibility of pitch inflection is at present not prohibitively hard to achieve. It is not necessary to build new wind or string instruments to play music in this way.

So long as the intervals used to find the exact pitch levels are all familiar from traditional music, no extensive unfamiliar ear-training is necessary to make possible a great variety of microtonal intervals. And since the crucial intervals are precisely those which predominate in the pitch texture of triadic music, a single harmonic system includes combinations from the smoothest consonances to dissonances stronger than any possible in twelve-tone equal temperament. Twelve-tone and other types of serial pitch organization can be used in such a pitch system, as *optional* devices of partial or total thematicism. The thematic process is not expected to replace harmonic organization, but instead is freed from this responsibility to adopt a parallel role in the achievement of musical intelligibility. Thus we can avoid two of the most restricting characteristics of twelve-tone music: its banishment of simple consonance and the weakness of its large-scale harmonic logic.

It seems clear that we have long ago moved into a post-tonal period in the history of music. The possibilities of triadic tonality have been worked over for so long a time and in so many ways that the meanings once powerfully conveyed by its musical syntax are blunted and overfamiliar. Just as maxims and proverbs easily become truisms or platitudes through mere repetition, musical styles similarly deteriorate with overuse. Those who have most to do with originating musical meaning, composers, are always the first to notice the deterioration. The contemporary musical scene is now dominated by non-tonal, non-triadic music. Cultural lag has not yet brought audiences, performers, or impresarios to the point where this stylistic shift is manifest; but the willing acceptance of works in the immediately preceding style, neoclassicism, is no longer unusual.

Neoclassicism is like a retrospective summary of the past. In undeniably contemporary idioms it sums up an era of musical history: the tradition of European music since the medieval period. Thus

it is a culmination rather than a new beginning. The revolutionary movement which began with atonality nows seems to point in the direction of a music not basically pitch-oriented. If the use of pitch as a basis of musical organization is not to fall into eclipse in serious contemporary music, a considerably broadened horizon of possibilities must be explored.

I have felt for years that conventional tonal organization permits one only parody today, whether comic, serious, or unintentional; and parody is ultimately too restricting to be of lasting interest. But I have also felt that twelve-tone method has limited the emotional scope of musical composition rather drastically, and that many of its devices (especially some of the methods of so-called total serialism) are meaningless as audible organizational devices. The often-noted observation that the musical results of "total organization" and those of "total chance" are not distinguishable without footnotes, indicates clearly that too many of the organizational devices of total organization are not being perceived. Perhaps they cannot be; perhaps time will change that. But I believe that the above suggested methods supplement serial technique while neither denying its value nor interfering with its effectiveness nor functioning irrelevantly to it. I also believe that proportional organization can more easily do without serial organization than vice versa.

It is time we broke the magic—and vicious—circle created by the supposed polarity of total serialism and total chance. We do not really have to choose between a hair shirt and chaos.