COMPUTER ASSISTED COMPOSITION IN EQUAL TUNINGS: TONAL COGNITION AND THE THIRTEEN TONE MARCH

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ABSTRACT

This essay first describes the technological method I used to create a working environment for creating music with equal tunings in divisions of the octave other than twelve. It then makes some general comments on the tuning of thirteen equal tones, and presents a partial analysis of my own composition in this tuning. This composition, simply entitled “Thirteen Tone March” was created as part of a project to attempt the composition of tonal music in tuning systems with numbers of equal tones higher than twelve. The essay concludes with an aesthetic discussion of the reasons for such a project, and its results.

1. A WORKING ENVIRONMENT FOR COMPOSITION IN EQUAL TUNINGS

In standard equal tuning, the octave is divided into twelve equal steps. Given any frequency $F$, one can determine the frequency $f$ of any note $x$ that is $y$ of these steps away from $F$ by the following formula:

$$ f(x) = F \cdot 2^{\frac{y}{12}} \quad (1) $$

Intuitively enough, the resulting frequency is $y$ steps above $F$ if $y$ is positive, and below $F$ if $y$ is negative.

To divide the octave into equal steps numbering other than 12, we can replace 12 with a variable, $d$ (for “division” of the octave.)

To implement this in a MIDI interface,

- Let $M$ be the MIDI note number that corresponds to the known frequency $F$.
- Let $x$ be the MIDI note number of a key that’s been played.
- The distance $y$ can now be understood as the difference in the MIDI note numbers of the played and known notes, or $x - M$. (This order preserves the positive-negative relationship described above).

Thus, given a known note $M$ with frequency $F$, the frequency of any note $x$ can be expressed as below:

$$ f(x) = F \cdot 2^{\frac{y}{d}} \quad (2) $$

Using the formula above, I created a retuning patch in the Max/MSP environment that lets the user assign values to $d$, $F$, and $M$; it then accepts MIDI input and outputs frequency in Hz (and passes velocity through unchanged). Its output can be sent to any synthesis module that accepts frequency and velocity. To ensure problem-free polyphony, a simple but safely redundant mechanism is put into place.

As an example, the common reference pitch “A 440” would let $M$ equal 69 (on some keyboard controllers) and $F$ equal 440.000 Hz. Playing a note on a MIDI controller 12 physical keys above the given A would let $x$ equal 81, $x - M$ would be 12, and if $d = 12$ then $f(x)$ would be 880.000 Hz, one octave above the reference note. If $d$ were 13, however, one would need to play a note 13 physical keys higher then the reference note to produce an octave. It would look like an A-sharp on the keyboard, but would sound an A. Similarly, playing a C key three physical keys above the reference A while $d = 12$ would obviously result in a C (523.251 Hz) or 3/12 of an octave. While $d = 13$, playing the same key would sound only 3/13 of an octave above A (516.323 Hz), while $d = 18$ it would sound 3/18 of an octave above, and so on.

The physical key corresponding to the reference note $M$ will be the one key that is never retuned, and all of the other keys on the controller will be retuned around it. For this reason, I refer to the reference note as the “pole.” $F$ and $M$ can be set together by picking a pole; in this case it is assumed that this note will have the same frequency that it does in standard tuning. In my scores written for this environment, the tuning is indicated at the top of the page by giving values for $d$ and for the pole.

2. TUNING IN THIRTEEN EQUAL TONES

I greatly enjoy Easley Blackwood’s microtonal compositions and am impressed with his essay from around fifteen years ago that proposes some useful theories for dealing with nineteen, seventeen, sixteen and fifteen note equal tunings, especially in that his approach to these tuning systems is well adapted to the idiosyncrasies of each system [1]. My approach to the tuning of 13 equal tones per octave is to take advantage of the ambiguity that can arise from different ways of approximating tonal elements of standard 12-note tuning. After working in this tuning for some time, I composed the Thirteen Tone March, each
section of which showcases a different interesting aspect of the thirteen note equal tuning.

As for notation, I simply add an extra, thirteenth note to our usual twelve note system. This note is C-flat, written with a backwards flat symbol as a visual reminder that this note is different than usual and is no longer enharmonic with B-natural. It would, in theory, be enharmonic with B-sharp (notated with some form of modified sharp symbol), but no use for this was found in the March.

It is possible to use the Max/MSP patch described above as a tool for performing live in alternate equal tunings as well. When this is done, I prepare an “action-based score” in which the notation shows the physical keys on the keyboard that the keyboardist will play, instead of the resulting sound. However, the sound-based score is more convenient for the analytical purposes of this paper, and the first page of the sound-score is included at the end of this document. A recording is available upon request.

3. TWO MAJOR SCALES WITH THE SAME TONIC

In the tuning with 13 equal tones to the octave, small melodic intervals naturally sound closer to their standard counterparts than wide ones; each 13-note half step is only 1/13 of a standard half step flat, after all. Of course, these fractions add up the more steps are taken, but this additive effect is not as noticeable as the result of stepwise motion as it is when larger intervals are played melodically. Thus, if one starts at the tonic (we’ll use F since the March starts in F) and plays descending or ascending intervals in the pattern of a major scale, the sound approximates a major scale until the eighth step, when we arrive not at the tonic F but at an F-sharp or F-flat (we are, after all, now 12/13 of a half step off: inverted, this is one entire 13-note half-step). Much of the ambiguity that I composed into the March can be said to arise from an interplay between these two scales, which are shown in figure 1.

4. THE FIRST STRAIN: COMPETING APPROXIMATIONS OF THE MAJOR TRIAD

The first strain (mm. 5-21) features an interplay between two approximations of the major tonic triad. Triads whose sounds approximate that of the standard 12-note tuning’s major triad can be made by combining the third and fifth from either of the above scales. A-sharp and C will be a little higher than normal, while A and C-flat will be a little lower than normal. It is convenient to think of these two tonic triad approximations as ‘tall’ (F A-sharp C) and ‘short’ (F A C-flat). (Mixing thirds and fifths from different scales does not produce approximations of the F triad; (F, A, C) sounds closer to a C major chord in inversion, and (F A-sharp C-flat) doesn’t sound like a triad at all.) Figure 2 shows the two acceptable approximations of the tonic triad.

Use of these two different tonic triads can be seen at the beginning of the first strain. The introduction (mm. 1-4) presents the short tonic chord; the first strain then begins with the tall tonic chord in measure 5 moving to a dominant chord (to be discussed later) in measure 6, which resolves in measure 7 to the short tonic chord.

A more melodic example occurs in measure 11. To finish the sequence set up in measures 8-10, the melody in measure 11 could easily have been C, A-sharp, F— the tall major chord. Instead of the F, however, the fifth and third of the short major chord are heard, and the tonic F is finally heard in measure 12.

In both of these examples, the short major chord is treated as the correct one, at least in that it gets the final word. An example of the opposite order can be seen in measure 19. This time, however, the gesture takes place on the level of the dominant, so a look must be taken at the dominant chords first.

Because there are two approximations of the dominant note (C and C-flat in this case), and two approximations of any major chord, there are four total possibilities for a dominant chord. All four possibilities are shown in figure 3.

In standard March form, the first strain is expected to end on the dominant, but which one? Of the four dominant chords, only the two that have E-G as their upper two notes contain their third as scale degree seven and their fifth as scale degree two of the F scales shown in fig. 1. (The other two contain notes not found therein: E-sharp in one, G-flat in the other.) Of these, I decided to favor the one that contained C-flat at the end of the first strain: while it may be a tall dominant chord, it is the short dominant note that is confirmed, just as the same note, C-flat, was preferred at the endings of phrases previously in the first strain, as the fifth of the short tonic chord.
5. THE SECOND STRAIN: CHROMATIC INTERVALS AND A UNIQUE MODULATION

Besides showcasing the half-steps of the 13-tone tuning, the second strain makes use of an interesting property of this tuning system to bring about a unique modulation. Both the tall and short major chords use the same interval between their third and fifth, a minor third. Because this is so, the upper notes of a tall tonic triad could also be the upper notes of a short major chord built on the note a half step above tonic. Figure 4 shows this relationship. Tonicizing a chord one half-step above tonic can be awkward in twelve tones, but it can be very smooth in thirteen. An example of such a tonicization occurs in measures 28-29.

Figure 4. The Tall F chord and the short F-sharp chord contain the same upper two notes.

6. THE TRIO: LARGE MELODIC INTERVALS AND A QUESTIONABLE ENDING

The third section of the standard March form, called a "Trio," is usually said to be in the key of the subdominant. In my March, I decided once again to favor the lower of the two scales, and use B-flat as the subdominant in the trio (not shown). In contrast to the chromatic motif of the second strain, the trio features wider intervals that sound more noticeably out-of-tune in the 13-tone system. To increase energy, the melodic leaps tend to get larger as the section moves on.

Because it's repeated, the trio has a first and second ending. The first ending presents the short tonic chord (B-flat, D-flat, F-flat), but the second ending presents the tall tonic chord (B-flat, D, F). This is a reversal of the usual finality of the shorter major chord. My reasons for doing so are this time not theoretical but psychological, and will be discussed in the final section of this paper.

7. TONALITY WITHOUT THE TONAL SYSTEM

One of the goals for this project was to explore tonality via parody; the parody being not only of the standard "military march" form but also in that the 13 tone tuning was used to create a parody of traditional tonality. The tonal aspects of this form are recognizable even to someone untrained in their analysis, and yet, the system of twelve tones by which we often define tonality is missing or at best approximated. What does it say about our relationship to tonality that we can hear it when it isn't technically there?

One obvious theory about this would be that a listener acculturated in twelve-note tonality, if not specifically military marches, would unconsciously try to find familiar tonal structures in this music. Related to this is the idea of "tolerance," invoked by many music analysts in order to dismiss pitch inaccuracies during a performance or differences in historical tuning systems as non-fatal to an analysis in 12 theoretically equal tones. The idea is that our ears, acculturated to music in 12 tones, will ignore deviations from theoretically exact intervals within a given tolerance range. In tonal music in 13 tones, there are often two notes than can approximate any one note of the usual 12-note system, as demonstrated earlier; and the composer can utilize this ambiguity to confuse the listener's usual subconscious mechanism that ignores pitch deviations, and to challenge our ability to "tolerate" deviations and still hear this music as tonal.

With this in mind, there were times in this composition at which I took measure to keep the listener from becoming too comfortable with the new tuning system—to heighten the sense of parody and humor, but also to experiment with our subconscious tendencies toward tonal listening. In an early version of the first strain in which I had used only one dominant note in the bassline (C, and never C-flat) my ears found it easy to simply adjust to the extra-wide perfect fifth. In the final version, however, C and C-flat interchange in unpredictable ways. While the C-flat probably sounds like a "wrong note" in the bassline of measure 8 (after so many bassline gestures featuring only C and F), it sounds more correct in measure 11 (now supported by the melody note) and more or less confirmed in measure 20 (approached with a tall dominant note of its own, G). In this and other ways, I took measure to make sure that the listener does not simply grow accustomed to a slightly out-of-tune version of twelve-note tonality: I made the most of the ambiguities of the thirteen-note system. And yet, the tonal moments in the piece are unmistakable.

Theorists often speak of music in terms of expectation; its dramatic power is said to come from the denial and eventual fulfillment of what we expect to hear. In a traditional tonal context, we expect to hear the tonic at the end of the piece. As mentioned earlier, I ended the piece on the tall tonic instead of the usual subconscious mechanism that ignores pitch deviations, but also to experiment with our subconscious tendencies toward tonal listening. In an early version of the first strain in which I had used only one dominant note in the bassline (C, and never C-flat) my ears found it easy to simply adjust to the extra-wide perfect fifth. In the final version, however, C and C-flat interchange in unpredictable ways. While the C-flat probably sounds like a "wrong note" in the bassline of measure 8 (after so many bassline gestures featuring only C and F), it sounds more correct in measure 11 (now supported by the melody note) and more or less confirmed in measure 20 (approached with a tall dominant note of its own, G). In this and other ways, I took measure to make sure that the listener does not simply grow accustomed to a slightly out-of-tune version of twelve-note tonality: I made the most of the ambiguities of the thirteen-note system. And yet, the tonal moments in the piece are unmistakable.

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8. REFERENCES

Thirteen Tone March

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