Focus on Drumset/Studio Percussion

Four Loops

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FOUR LOOPS WAS PERFORMED USING A Roland S-550 sampler, Alesis HR-16 Drum Machine, Yamaha PMC-1 percussion controller equipped with six snare pads and sustain/patch change pedals, and a Roland Pad 80 (Octapad II).

I have long been interested in the relationship between a few basic mathematical principles and their application to musical processes. Many musical qualities are indeed expressed in numeric terms. Meter and its accompanying measurement of note values (rhythmic notation), tempo expressed in terms of solar time (beats per minute or bpm), and pitch expressed as a rate of vibration (cycles per second or cps)—again in reference to solar time—are all bound to numeric conceptions. Most musical composition treats each of these qualities as separate non-related entities while it is evident they have at least numeric conception in common.

HISTORY

Several years ago, I had the pleasure of studying percussion with Alex Lepak. One small part of that study included polymetric analysis. His method of analysis was so logical—being based on the mathematical expression a:b (ratio)—and his method of presentation so stimulating, that I continue to be fascinated about the nature of polyrhythms, their motivic and structural application, and their inherent consequences to musical form. In fact, I have used polyrhythms as motivic and structural premises to all of my compositions. The mathematical nature of polyrhythmic analysis seemed to present a possible link between some of the numeric/musical qualities mentioned above.

I began working on Four Loops in 1981. My original intent was to write a polyrhythmic/polymetric composition for acoustic percussion instruments employing three percussion sections. Each section was comprised of a drum set player and two percussionists. Each section would play the same notes (derived from a very basic rock back-beat) at different but related tempos:

♩= 120, 160 (120 * 4/3) and 180 (120 * 3/2) bpm

Because of the complexity—both notationally and aurally—it seemed necessary to use a conductor for each section in order to keep things synchronized. Although the basic conception of Four Loops seemed simplistic, the actual composition was exploding into a logistical nightmare with little hope of ever being publicly realized. That version of the tune was promptly shelved, but not the idea.

Some years later, I had the opportunity to experiment with a sampler. After becoming familiar with sampling technology, not only was a solution to the problem of Four Loops discovered, but some other interesting possibilities became apparent. Four Loops was realized some months later using a sampler, four track tape recorder and several overdubs. It existed in that state for several years.

Meanwhile, increasing sophistication of percussion controllers and tone generators - brought about by advancing technology and the MIDI specification - opened new doors in the area of real-time performance. My interest in the performance, compositional and educational fields of electronic percussion seemed to grow with each advance in the industry. With the installation of the Electronic Percussion Teaching Studio at the University of Western Ontario, I have been able to translate some of my compositions, which previously existed in the realm of acoustic percussion, into real-time electronic percussion performances. At the 1990 Ontario Chapter Day of Percussion, I had the opportunity to perform two of my compositions for solo electronic percussion. This article concerns some compositional techniques employed in Four Loops. These techniques were made possible by both sampling technology and electronic percussion instruments.

THEORY

The Compact Oxford Dictionary defines "ratio" as:

> *"...The relation between two similar magnitudes in respect of quantity, determined by the number of times one contains the other (integrally or fractionally) ..."*

It was just this idea of ratio - the relation between two similar magnitudes - that formed the basis of Four Loops. The expression a:b easily explains the notion of polyrhythm when both terms of the expression are similar - rhythm:rhythm. Indeed several similar terms can be used in the expression and still comprise the notion of polyrhythm - a:b:c:d or rhythm:rhythm:rhythm:rhythm. However, consider the following expression of dissimilar terms - rhythm:pitch:harmony:tempo. Traditionally these musical terms or notions have been interpreted as separate entities but electronic music and sampling technology have contributed to making grey what used to be black and white.

Four Loops is an experiment in the possible connectivity between rhythm, pitch, harmony and tempo.

Rhythm and pitch can be very closely related. If an infinite accelerando is applied to a short repetitive rhythmic fragment, eventually that rhythmic fragment will turn into a pitch. This effect can be demonstrated by programming a series of very short note values into a drum machine and adjusting the tempo. Try using a series of consecutive 32nd notes as in Example 1a or non-consecutive (random) 32nd notes as in Example 1b.

Example 1a

Example 1b

Loop (endlessly repeat) the pattern and adjust the tempo within the range 150 and 250 bpm. You will hear a noticeable rise and fall in pitch. (Lower pitched instruments - bass drums or tom toms - are the best choice for this experiment.) Sweeping the entire bpm range of the drum machine, a transition between repetitive rhythm and pitch should be discerned. Any pitch can be thought of as a very fast repetitive rhythm and any repetitive rhythm can be thought of as a very slow pitch. The following chart shows two different perspectives of rate of vibration for a given pitch (A=440) progressively halved or shifted downward by one octave.

Rates of Vibration

Cycles Per Second	Beats Per Minute
A 440	26400
A 220	13200
A 110	6600
A 55	3300
A 27.5	1650
A 13.75	825
A 6.875	412.5
A 3.4375	206.25
A 1.71875	103.126
A 0.859375	51.5625
A 0.4296875	25.78125

Values on the left express the rate of vibration in cycles per second. Corresponding values on the right express the rate of vibration in beats per minute (cps * 60). Rates of vibration above A 27.5 cps or 1650 bpm are quite discernible as pitch while rates of vibration below A 3.4375 cps or 206.25 bpm are discernible as repetitive rhythm. Rates of vibration between A 27.5 and 3.4375 cps are nebulous and might be considered either pitch or repetitive rhythm depending on the listener. For a colorful analogy, imagine rates of vibration generally above 412.5 bpm as infrared repetitive rhythm and rates of vibration generally below 6.875 cps as ultraviolet pitch.

Intervalic/harmonic structures resemble the same characteristics described above except that now, the concept of polypitch and/or polyrhythm must be entertained. To address this notion from a different perspective, take a step backward to the 6th century B.C. Pythagoras determined intervalic relationships by fractional expressions of a reference pitch. For example, using a freely vibrating string fixed at two points, by stopping that string half way between its length, the string vibrates twice as fast and produces a pitch one octave above the reference pitch. Eventually, the Pythagorean scale - corresponding to Dorian Mode scale steps - was given as:

C	D	E	F	G	A	B	C
1	9/8	81/64	4/3	3/2	27/16	243/128	2

(Letter names for notes apply for all diatonic transpositions.)

Note in particular the relationship between:

C	F	G	C
1	4/3	3/2	2

If a diatonic transposition to A major (A 440 cps) is applied, then the resultant values for the fourth, fifth and eighth degrees of the scale are 586.6 (440/3*4), 660 (440/2*3) and 880 (440/1*2) respectively.

If two notes are sounded simultaneously, their relative rate of vibration can be expressed as a ratio of the reference pitch just as polyrhythm can be expressed as a ratio. If C or 1 has a hypothetical rate of vibration of 3 cps then F's rate of vibration would be 4 cps and could be alternately expressed as 4:3. And if C or 1 had a hypothetical rate of vibration of 2 cps then G's rate of vibration would be 3 cps and could be alternately expressed as 3:2. Similarly, if C or 1's rate of vibration has a hypothetical rate of vibration of 1, then F = 1.3 (1 / 3 * 4) and G = 1.5 (1 / 2 * 3). These hypothesis can be tested using samplers. To carry out the following experiments, you will need a keyboard sampler (or a sampler module midied to a keyboard controller) and a drum machine or sequencer-controlled tone generator.

METHOD

1. Using a drum machine or sequencer, program the following source rhythm using a snare drum or closed hi hat sound.

Example 2

2. Adjust the tempo to exactly ♩=120 bpm.

3. Sample the rhythm. You will need more than two seconds of sample time.

4. Assign the original sample to note C4 or the C closest to the middle of your keyboard. Make sure that the sample's pitch and tempo are the same as the source pitch and tempo.

5. Map the sample to the entire range of the keyboard. Some samplers do this automatically while others require individual note assignment.

6. Trim the wave start time to correspond with the first instance of attack. Depending on the threshold setting of the sampler, some silence may appear before the actual attack and must be eliminated. While visual editors are helpful, your ear is probably the best judge. Play the lowest note available - or transpose downward as far as possible - and note the delay time between when the key is pressed and the sound is heard. It is always advisable to save a copy of the sample before any editing is performed.

7. Loop the wave. Set the loop start point to the wave start time. This should now correspond to the first instance of attack. Set the loop end point by ear so that the looped rhythm produces a perfect repeat. Again, visual editors are helpful, but your ear should be the final judge. The end product can be tested by playing the drum machine source rhythm and the sampler (note C4) simultaneously. The two rhythms should remain in very close synchronization over a long period of time.

An alternative method is to sample five quarter notes and proceed as above, but set the loop end point just prior to the attack of the fifth note.

OBSERVATIONS

Play (hold the key down or use a sustain pedal) C4. The sampled rhythm should be playing at:

♩= 120 bpm.

Now play F4. The sample will now be playing at:

♩= 160 bpm (120 / 3 * 4).

Also note that the pitch has been raised by an equivalent amount. Play G4. The tempo is now

♩= 180 bpm (120 / 2 * 3)

and the pitch is correspondingly higher. Play C5. The tempo is now

♩= 240 bpm (120 / 1 * 2),

and the pitch is one octave higher than the reference pitch.

Now play C4 and C5 simultaneously. You should hear the reference tempo and pitch along with a double time tempo one octave above. Play C3, C4 and C5 simultaneously. Listen for the reference sample as well as a half time sound wave shifted one octave lower and a double time sound wave shifted one octave higher. Play F3, F4 and F5. Note the same results are achieved except that all pitches and tempos are shifted up by 4/3. The corresponding new tempos are:

♩= 80, 160 and 320 bpm.

G3, G4 and G5 correspond to C3, C4 and C5 shifted up by 3/2. The new tempos are:

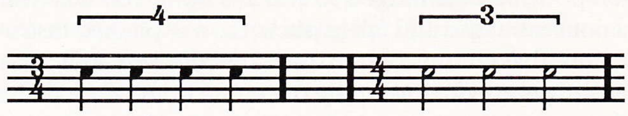
♩= 90, 180 and 360 bpm.

Now play C4 and F4 simultaneously. The two sounds are a fourth apart in pitch and have tempos of:

♩=120 and 160 respectively.

However, these tempos are now perceived as the polyrhythm 4:3 (or 3:4 depending on which note is chosen as the reference note).

Example 3



C4 and G4 produce two sounds a fifth apart with tempos of:

♩= 120 and 180 bpm

corresponding to the polyrhythm 3:2 (or 2:3).

Example 4

The perception of polyrhythm and tempo change can be controlled by octave doubling. Play C3 and C4 simultaneously. Using C3 as the reference pitch, you should have a reference tempo of:

♩= 60 bpm.

Thinking in terms of 4/4 or common time, four bars of this rhythm takes 16 seconds. Now play the chord F3, C4 and F4. Four bars of this rhythm takes 12 seconds (16/4*3) at a perceived tempo of:

♩= 80 bpm.

Four bars of the chord G3, C4 and G4 takes 10.66 seconds (16/3*2) at a perceived tempo of:

♩= 90 bpm.

Note also the increased polyrhythmic complexity by the addition of the lower octave.

Throughout the above experiments, you may have noticed the relationship to the harmonic root progression

I,IV, V, I. If you have another synthesizer or piano (or vibraphone, marimba or xylophone) and two more hands at your disposal, try playing the following:

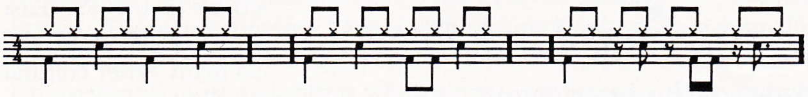
Example 5

Rhythm progression (Sampler)	**Chord Progression (Synthesizer)**
C3, C4,	C4, E4, G4, C5
F3, C4, F4	F3, C4, F4, A4
G3, C4, G4	G3, F4, G4, B4

Hold each progression for the equivalent of four bars according to each progression's tempo. The result is harmonic root progression tied to corresponding changes of tempo, pitch and polyrhythmic complexity. In this respect, the sense of musical tension and relaxation seems to be elevated.

For even richer rhythmic texture, re-sample the original source rhythm with the rhythms in Example 5. Try adding hi-hat parts as well.

Example 6



And if you feel particularly adventurous, try sampling examples of different meters - simple, compound and irregular - containing rational and/or irrational note groupings.

Example 7

SUMMARY

I have found great enjoyment and stimulation in exploring rhythmic relationships and possibilities using the techniques described above. While this article has dealt with only basic applications of these techniques, their potential as educational devices, compositional tools and aural stimulants is almost overwhelming. Perhaps someday the notion of perfect pitch recognition will have its counterpart in the notion of perfect rhythm recognition.

The Compact Edition of the Oxford Dictionary, 2 vols. Oxford University Press, 1971, 3rd Printing 1973, s.v. "ratio".

Backus, John. The Acoustical Foundations of Music, 2nd ed., (New York: W.W. Norton & Company Inc., 1977), 138.

While samplers and synthesizers generally use Equal Temperament and not Pythagorean Temperament, I have found that for the purpose of the experiments contained in this article, the margin of error is within acceptable limits.

All tempo indications are based on Pythagorean relationships. Any real discrepancy in tempo is caused by this variation in temperament. ■

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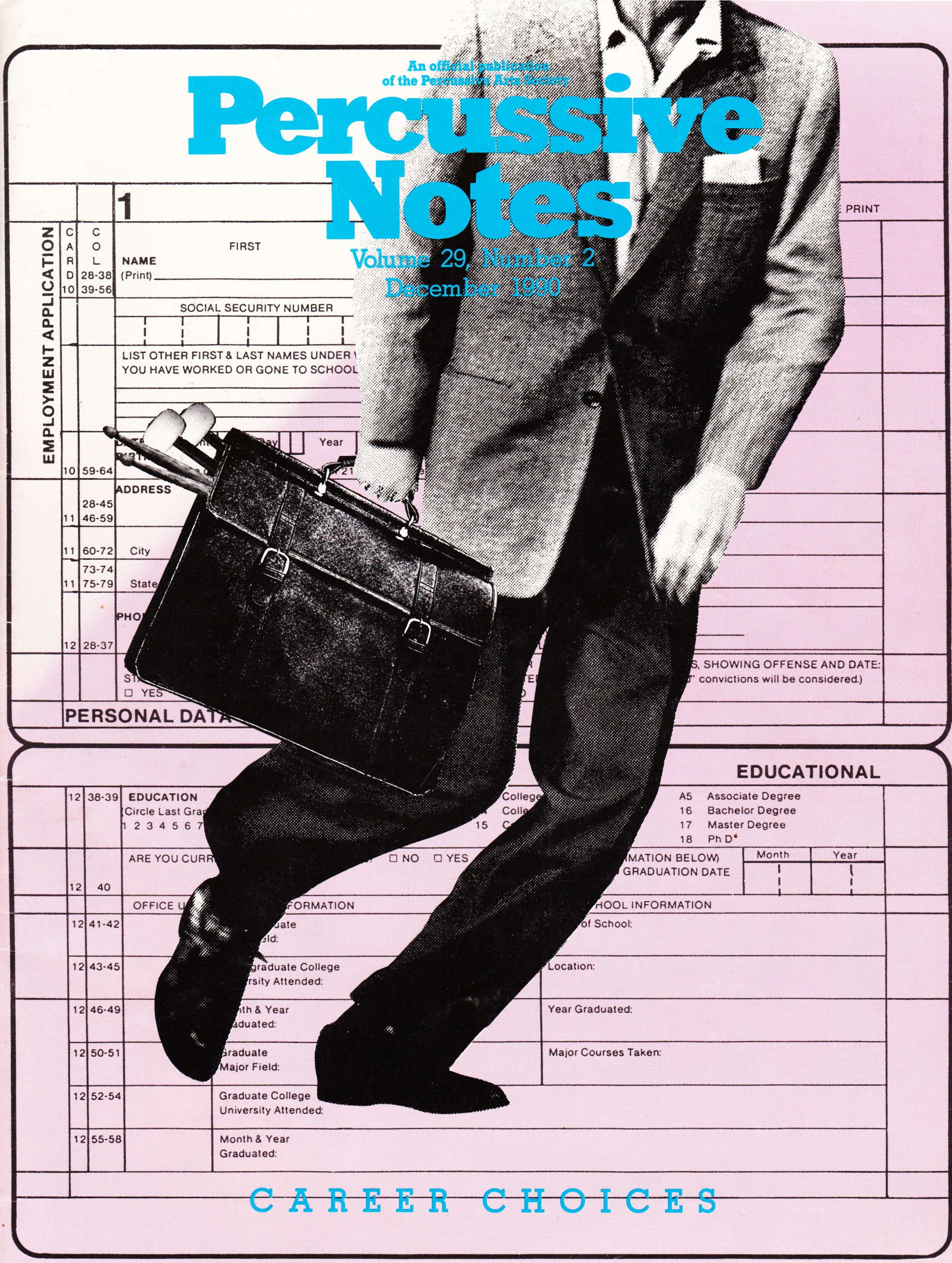

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