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UNIVERSITY OF CALIFORNIA,
IRVINE

Metric Interplay: A Case Study In Polymeter, Polyrythm, And Polytempo

THESIS

submitted in partial satisfaction of the requirements
for the degree of

MASTER OF FINE ARTS

in Music

by

Martim Schneider Galvão

Thesis Committee:
Professor Christopher Dobrian, Chair
Professor Nicole Mitchell
Continuing Lecturer Bryan Jackson

2014

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ABSTRACT

Metric Interplay: A Case Study In Polymeter, Polyrythm, And Polytempo

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This thesis paper examines the use of *polymeter* as a compositional technique. I compare the terms polyrythm, polymeter, and polytempo, and discuss their use in selected passages from the music of Steve Reich, Iannis Xenakis, and Frank Zappa. I also discuss polymetric and polyrythmic interplay in my own work, using examples from my capstone MFA project, *LAVA GLASS*.

Composers have taken various approaches to incorporating polyrhythm and polymeter into their music. In this paper I explore the implications of metric, rhythmic, and temporal incongruity in music with specific examples from composers who I feel have used these techniques with the greatest aptitude. For the sake of clarity I will distinguish between the terms “polymeter,” “polyrhythm,” and “polytempo.”

Although one prominent source defines polyrhythm as “the superposition of different rhythms or metres”¹ I will, for the purposes of this paper, distinguish between rhythms that recur every measure (measure-preserving) and those that recur at a phrase level (beat-preserving) by referring to them as polyrhythm and polymeter, respectively. The main difference is the scope over which the superposition of rhythm happens – polyrhythms syncing up every measure and polymeters syncing up every time the simultaneously occurring meters reach the lowest common multiple between them.

Polymeter:

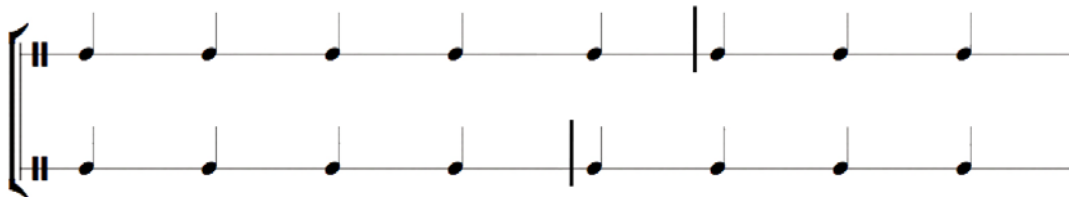


Figure 1.1: Polymeter

Polyrhythm:

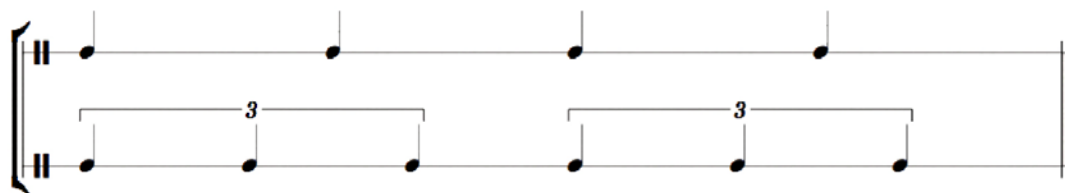


Figure 1.2: Polyrhythm

Polytempo:

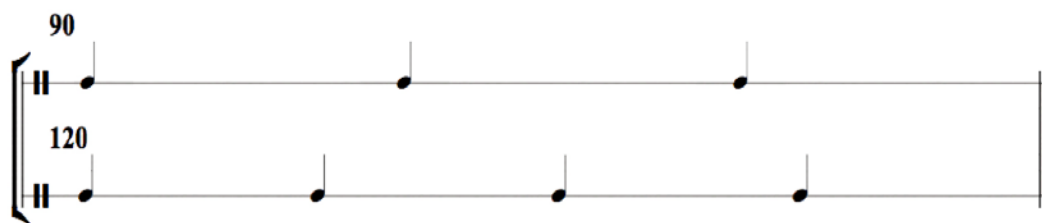


Figure 1.3: Polytempo

1 "Polyrhythm." *Grove Music Online. Oxford Music Online.* Oxford University Press, accessed October 16, 2013, <http://www.oxfordmusiconline.com/subscriber/article/grove/music/22059>.

If we wish to abstract the concept of polyrhythm, polyemeter, and polytempo even further, though, it is not difficult to see how the same results may be achieved by using any of these techniques. A 6:4 polyrhythm like the one above, for example, in which superimposed quarter note rhythms align every measure, may also be presented as polytempo, in which case we can observe the polyrhythm as two simultaneously occurring tempos with a 6:4 relationship (ex. 180 bpm for the 6/4 pattern and 120 bpm for the 4/4 pattern.) We may likewise suppose that the polytemporal situation is also polymetric, though if we ignore meter the difference would be imperceptible.

The interpretations of rhythmic dissonance are manifold and very much depend on a listener's own perception of rhythm and phrase structure. In order to illustrate these flexible interpretations I have chosen to draw examples from the works of three composers who, by incorporating polyrhythmic, polymetric, and polytemporal concepts into their compositions, demonstrate the possibility for rhythmic complexity and richness afforded by such techniques. They are Steve Reich, Frank Zappa, and Iannis Xenakis.

Let us begin with a look at the music of Steve Reich, specifically one his seminal works, *Drumming* (1970-71). The piece was composed over the course of roughly one year following Reich's return from Ghana, where he studied drumming with Ewe master drummer Gideon Alorwoye². Reich recorded each lesson with Alorwoye and afterward played the tapes back at a slow enough speed so as to be able to transcribe the individual patterns. By doing so he noticed that different instrumental patterns present in Gahu music, although rhythmically compatible either by a simple or polyrhythmic relationship, were not bound by any sort of attachment to the first downbeat of each measure.

This, in simplified miniature, is the essence of African rhythmic structure: several repeating patterns of the same or related lengths and each with its own separate downbeat.³

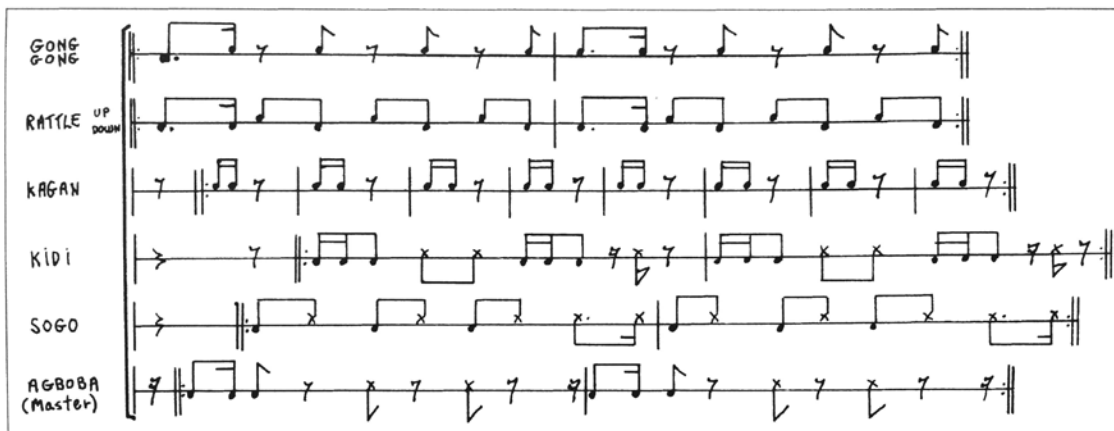


Figure 2.1: Gahu Music

2 Reich, Steve. *Writing on Music, 1965-2000*. New York: Oxford University Press, 2002, 55
 3 Ibid, 57

The way in which Reich has established the measure lines for each pattern in his transcription is a clear indication of his perception of meter in this type of music. Rather than simply dropping all of the patterns into 4/4, Reich maps the relationship between each instrument in a polymetric, albeit very closely related, way. The top gong line is an eight quarter note long phrase, whereas the rattle part directly below is exactly half the length at four quarter notes. The third line, a one quarter note long kagan pattern, is basically the tactus of the whole piece but displaced by one eighth note. The bottom three lines are all four quarter notes long but displaced by one and a half quarter notes (kidi), one quarter note (sogo), and a sixteenth note (agboba), respectively. This rhythmic displacement is where we start to see the influence of Reich's time in Africa on his compositional approach to *Drumming*. The variability of the displacement is crucial to our understanding of *Drumming* and how the underlying process of rhythmic phasing works. As an example let us look at an excerpt from the first movement:

The image shows a musical score for three drummers. The first three staves are labeled 'DRUMMER 1', 'DRUMMER 2', and 'DRUMMER 3'. Each staff contains a rhythmic pattern of eighth notes. Drummer 1 starts at the beginning of the measure. Drummer 2 starts two quarter notes later. Drummer 3 starts one quarter note later than Drummer 1. The fourth staff is labeled 'COMPLETE RESULTING PATTERN OF DRUMMERS 1, 2 AND 3' and shows the combined rhythmic pattern of all three drummers, illustrating the phasing effect.

Figure 3.1: Drumming

If we examine the relationship between the patterns of drummers 1, 2, and 3 we see that they are rhythmically identical except for a shift in where each pattern begins within the measure. If drummer 1 is the original pattern, then we can observe that drummer 2's pattern is identical to that of drummer 1 except that it precedes drummer 1's pattern by two quarter notes. Drummer 3, then, precedes drummer 1 by one quarter note and lags behind drummer 2 by the same amount. The composite relationship between the three rhythms is mapped out on the fourth line.

Looking back to Reich's transcription of Gahu rhythms it is easy to see where he might have drawn influence for the shifting downbeats we see in *Drumming*. One observation worth noting, however, is that while in the Gahu example each player's pattern is unique from all other players despite any sort of rhythmic displacement, the excerpt from *Drumming* sees all three players keep the same exact pattern, only separated by one or two quarters note from any another player.

Another differentiating factor between Reich's music and Gahu drumming is what I will call the portability of the rhythm. Whereas in Gahu music the instruments are displaced by a fixed value and remain that way for the entire duration of the piece, Reich employs a technique known as phasing to shift the displacement of a given rhythm to a different starting position within the measure. The way in which Reich accomplishes this is by providing written instructions for the performers to gradually increase their tempo until they have achieved the desired displacement relative to another performer's rhythm. One could classify this as a temporary polytemporality in a piece that otherwise calls for strict agreement on tempo.

Reich's phasing technique can be traced back to early pieces for tape such as *It's Gonna Rain* (1965) and *Come Out* (1966) but it was not until *Piano Phase* (1967) that we see the technique applied to live performance. It is worth noting that Reich's use of phasing predated his trip to Ghana by at least five years and that his incorporation of the technique into *Drumming* therefore represents a coming together of newly acquired African influences with a rhythmic technique he had by this point fully developed. In an essay on *Drumming*, Reich describes the piece as his “final expansion and refinement of the phasing process as well as the first use of four new techniques:”⁴ He then goes on to describe these techniques as:

- (1) the process of gradually substituting beats for rests (or rests for beats);
- (2) the gradual changing of timbre while rhythm and pitch remain constant;
- (3) the simultaneous combination of instruments of different timbre and
- (4) the use of the human voice to become part of the music ensemble by imitating the exact sound of the instruments.⁵

The first of these techniques is the most relevant to this discussion due to the rhythmic implications of this type of gradual pattern building. To find an example we need look no further than measure 1, where the initial sequence of one eighth note (and eighth note rest) and five quarter note rests gradually develops into the main pattern of eight eighth notes and four eighth note rests one substitution at a time.

An interesting effect afforded by this substitution technique, specifically the introduction of the first pattern as one solitary eighth note, is that listener's sense of location within the measure is unclear. The subsequent substitutions, then, are clearly perceived as falling somewhere within a constant meter but with no explicit relationship to a downbeat. The resulting obfuscation of the downbeat is later combined with Reich's rhythmic phasing technique to further confuse the listener's sense of place within an unchanging meter. This technique is then reversed starting in measure 93, where Reich systematically replaces beats with rests of equal value.

The remaining three techniques are no less interesting from a compositional standpoint and can be viewed as a continuation of Reich's phasing approach. Whereas up to this point we have used the term 'phasing' exclusively in the context of rhythmic displacement, we can also think of it in terms of both timbre and instrumentation. Techniques two, three, and four represent phasing on a timbral and instrumental level – in which we see one or more voices give way to markedly different voices that, although unchanged in terms of rhythm and pitch, present the audience with a gradual shift in the quality of the sound. While rhythmic phasing displaces a pattern in time, the cross-fading of a pattern between two instruments displaces it in timbre. In this sense, the phasing technique can be interpreted as an agent for musical displacement, whether through rhythm, timbre, or instrumentation.

Reich's approach to polyrhythm and polymeter in *Drumming*, while clearly influenced by his studies of African music and dance, is a hybrid of devices of his own invention – namely phasing – and rhythmic techniques collected from Gahu and other African drumming traditions. This marriage of novel conceptual approaches to percussion music and traditional African polyrhythm allows for the introduction of Afrological musical concepts into a Western context without attempting to emulate the tradition itself.

4 Reich, 64

5 Ibid, 64

Frank Zappa, in many ways different from Reich, shared a similar appreciation for polyrhythmic and polymetric concepts. A self-taught percussionist, Zappa became interested in the music of Edgard Varèse at a young age, specifically works with an emphasis on percussion and rhythmic complexity such as *Ionisation* (1929-1931). Combining his interest in the works of 20th-century composers such as Varèse, Stravinsky, and Webern⁶ with more popular styles like rhythm and blues, pop, and jazz⁷, Zappa developed a hybrid musical style that is experimental and decidedly anti-mainstream but still rooted in the aesthetics of popular music. This duality is found throughout Zappa's career in various forms, one of which is his approach to polyrhythm and polymeter.

In a 1983 interview with *Guitar Player* titled "Coming To Grips With Polyrythms" Zappa discusses the use of polyrhythm in his song *Gee, I Like Your Pants* (1979) as well as his approach to polyrhythm in general. After condemning traditional Western music education as "straight up and down. You know: One, two, three, four; one, two, three."⁸ Zappa goes on to describe polyrhythm as a "very natural"⁹ approach to music making. He then cites African drumming as an example of polyrhythmic music than is inherently interesting and enjoyable to a broad audience (African and not) while still incorporating what would be considered dissonant rhythms. Harmonic dissonance, on the other hand, is described as "the thing that turns off most listeners."¹⁰ This is not a reflection of Zappa's own taste in tonality, but rather a reflection of how the general public might react to a semitone cluster. Zappa makes use of this aesthetic consideration in his own compositions, where we find many examples of rhythmic dissonance over harmonic content that would not seem out of place in a traditional Western musical context. Perhaps Zappa himself puts it best when he says "even quarter notes with dissonant chords on them are not very much fun to listen to, but if you have a diatonic setting or even a bitonal setting with complicated rhythmic stuff on it, there's no reason why that shouldn't be appealing to a wide range of people. People *like* rhythm."¹¹

6 Zappa, Frank and Occhiogrosso, Peter, *The Real Frank Zappa Book*, (New York: Poseidon Press, 1989), 31, 34.

7 Geoffrey I. Wills, "Zappa and the Story-Song: A Rage of Cultural Influences," chap. 7 in *Frank Zappa and the And*, ed. Paul Carr (Farnheim, England: Ashgate Publishing, Ltd., 2013).

8 Zappa, Frank. "Coming To Grips With Polyrythms." *Guitar Player*, April 1983.

9 Ibid

10 Ibid

11 Ibid

Let us look, then, at an excerpt from Steve Vai's transcription of Zappa's guitar solo from *Gee, I Like Your Pants*, in which the use of polyrhythm is not only abundant but also varied.



Figure 4.1: Gee, I Like Your Pants

The first measure starts with a nonuplet of 32nd notes that, inside of it, contains a triplet. Already we have made two leaps into rhythmic groupings artificial to the established meter, one of which must be subdivided into a subdivision. After a quick jaunt through the established time signature in the form of four 32nd notes we arrive at a sextuplet, within which we find a triplet descending figure, only to then jump into an inverted pedal point figure with a 27:3 relationship to the original meter, in which we again see the incorporation of artificial rhythms on multiple levels at once, this time in the form of two consecutive triplets under the umbrella of 27:3. Clearly we can see that Zappa's consideration of rhythmic interplay holds considerable influence in the structure and content of his improvisation.

Although the time signature of the song is 4/4 all the way through we can see how this does little in the way of limiting Zappa's incorporation of irregular rhythms over the established meter. The fact that this is a transcription of an improvisation must also not be overlooked. Although it exemplifies Zappa's ability to think polyrhythmically in real time, it also allows room for debate in terms of Vai's interpretation of the solo's rhythmic structure. Since it is unlikely that Zappa consciously improvised such complex arrangements of artificial rhythms during a live performance, one could also view the entire excerpt as simply a sequence of 32nd notes executed in tempo rubato so as to weave through and around the existing meter and tempo. In either case, it is a demonstration of Zappa's 'polyrhythm is natural' philosophy in action, although in this case we might also interpret the excerpt as an example of temporary polytemporality. Whereas the notated transcription is technically demanding for even highly skilled performers, the fact that Zappa is able to conjure up complex polyrhythms on the fly is a testimony to his comfort with and mastery of the technique. Polyrhythmic ideas permeate Zappa's style far beyond this excerpt, though, and figure prominently throughout his entire career - in many instances applied to notated percussion parts, perhaps most infamously in Zappa's notoriously difficult *The Black Page No. 1* (1977).

Let us turn, now, to the somewhat less frequently occurring and less analyzed issue of polymeter in Zappa's music. A well-known example and perhaps a good starting point for a discussion is Zappa's *Toads Of The Short Forest* (1970) from the album "Weasels Ripped My Flesh." The song starts in 6/8 (or 3/4 depending on one's perception of the beat), with the entire band adhering to the established meter without much in the way of artificial rhythmic groupings

save for a few triplets. The harmonic and melodic content of the piece also presents little in the way of dissonance or deviation from the form for the duration of the introduction. At 1:01, though, the song makes an abrupt transition to a brooding 5/8 pattern with dissonant screeches replacing the easygoing harmonic consonance of the introduction. At 1:33 a second drummer (drummer B) can be heard introducing a 7/8 pattern over the existing 5/8 pattern which, at 1:38, morphs into a 3/4 pattern when drummer A and the accompanying bass player make a quick transition. At this point the band is playing in several non-divisible meters while still maintaining a common sense of the beat. In other words almost every player is in a different meter but not a different tempo (approximately $\downarrow \approx 34$). At 2:10 Zappa can be heard providing a description of the polymetric arrangement:

At this very moment on the stage we have drummer A playing in 7/8, drummer B playing in 3/4, the bass playing in 3/4, the organ playing in 5/8, the tambourine playing in 3/4, and the alto sax blowing his nose.¹²

The piece never returns to the cheerful and consonant feel of the introduction and instead continues to develop into an ironic and almost farcical explosion of screeching horns and driving 5/8 drum patterns combined with misfit vaudeville-sounding interludes. All of this then pares down into a sequence of synchronized hits which become more and more abrasive in timbre and harmonic dissonance until the whole band slows down and ends the song on a coordinated hit which, after navigating a landscape of conflicting meters, timbres, and even musical styles, seems to be a testament to Zappa's mastery of organized musical complexity.

Another example of polymeter in Zappa's music can be found in *A Pound For A Brown On The Bus* (1969) from the album "Uncle Meat." Unlike the polymetric section in *Toads Of The Short Forest*, here Zappa employs a regularly modulating meter in the melody (3/4 to 4/4 and back) and a stable but different meter in the bass part (7/8) to create a structure that lines up every two measures. If we analyze the rhythm on an eighth note level we see that regardless of whether we look at the melody or the bass part we have 14 eight note beats per phrase.



Figure 5.1: A Pound For A Brown On The Bus
Source: Clement, Brett. *A Study of the Instrumental Music of Frank Zappa*. PhD diss., University of Cincinnati, 2009.

The result is a figure that conveys the effect of polymeter not only in where and when the different measure align but also in the sense of time resulting from the tactus of each meter. The top line, with its quarter note tactus, maintains a slower and more solid feeling throughout the

12 The Mothers of Invention. "Toads Of The Short Forest." *Weasels Ripped My Flesh*. Bizarre/Reprise. compact disc

piece while the eight note tactus in the bass line lends a sense of movement and urgency to the ostinato. The two lines maintain a close relationship due to Zappa's decision to fit them into what could be thought of as a two-measure-long hypermeter.

Be it through his intricate polyrhythmic groupings or his multi-tactus approach to polymeter, there is no denying that Zappa's compositional approach is heavily rooted in experimentation with rhythmic and metric perception. His notion of rhythmic and metric dissonance as a way to introduce complexity into music where harmonic dissonance cannot be vital to our understanding of Zappa's compositional aesthetic. Perhaps most striking is the ease with which Zappa incorporates the same compositional considerations of rhythm and meter into an improvisational plane – navigating long stretches of complex polyrhythms over commonplace meters to create rhythmic interest.

We have seen through the works of Steve Reich and Frank Zappa how rhythmic and metric dissonance might be used to create various effects on the level of beat induction and rhythm recognition. One commonality between all of these pieces, though, is the source of the sound – it always originates from a centralized location, be that a wall of speakers on stage or an arrangement of un-amplified percussionists. In the work of Greek composer, architect, and mathematician Iannis Xenakis, though, spatialization of sound plays as important a role as rhythmic and metric concerns. Let us look at how Xenakis uses the space around an audience to further amplify the perceptual effects of polymeter, polyrhythm, and polytempo.

Perhaps the best example of Xenakis' integration of all the aforementioned techniques into one piece can be found in his 1969 commission for the inaugural Shiraz Festival at Persepolis, *Persephassa*. The piece calls for six percussionists arranged in a hexagonal formation around the audience, with each performer playing four categories of percussion instruments: skins, wood, metal, and stone.

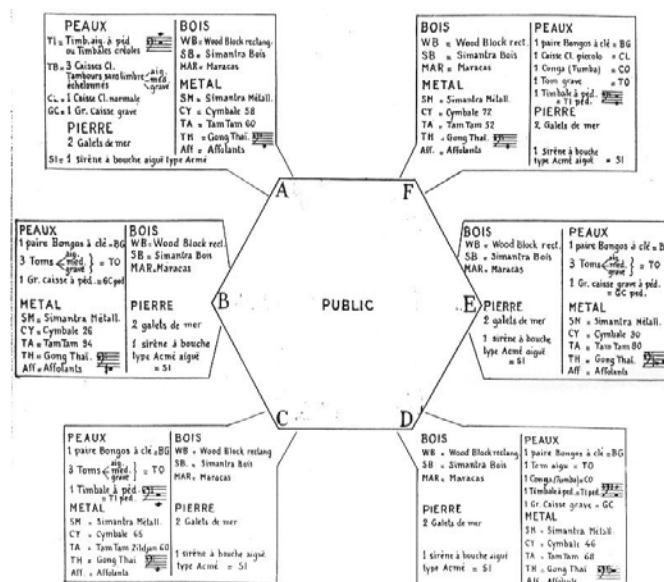


Figure 6.1: Persephassa Layout

The organization of the performers around the audience rather than in front on a stage is crucial to the effectiveness of Xenakis' metric, rhythmic, and temporal explorations.

The piece begins with all six percussionists in 2/2 time and with a distinct sense of uniformity between all six parts. Measures 1-6 are exactly the same for all six players and it is not until m. 7 that player A breaks from the group with a fortissimo quarter note on the high timbale. All six players remain in 2/2 with only quarter notes and rolls on skin instruments until m. 62, at which point the tempo drops from the original half note = 120 to half note = 72. This is also a transition into what can be described as an implied polyrhythm between the six parts, achieved through stretching out irrational rhythms so that they form a hypermetric polyrhythm.

A basic rhythm of two quarter note articulations per measure (one on beat 1 and one on beat 3) is established by players C and E in m. 62. Although the articulation of each attack can vary from a single strike to a roll, this basic rhythm is maintained in some sense for the next 15 measure. The polyrhythmic implication, then, is established by moving away from the initial interonset interval (IOI) of half a measure to any number of durations. The first performer to move away from the 2/4 relationship is player B who at m.62 uses irrational rhythmic groupings to establish an IOI of 9/10 of a measure¹³, leaving us with an implied relationship of 3.6/2. The process continues with player E at m. 67, who establishes an IOI of 5/6 of a measure and an implied relationship of 3.3/2, and then carries on with the remaining four players multiple times in the same voicing until m. 78, at which point player A introduces skins of different pitches. At m. 99 player A takes a solo lasting one 2/2 measure and is followed by players B, C, D, and E – all of whom solo for the duration of one 2/2 measure but with an implied polyrhythmic feel.

The result of all this is that all six players are able to follow the score without the use of any external aids, simply by maintaining a common meter and tempo between them. From the audience's point of view, though, the differing IOIs imply that each performer has gone off into a separate polyrhythmic relationship. Of course one could also view the relationship between the different parts as one of polytemporal or polymetric significance, however, because the next excerpt is a clear example of polytemporality I have elected to treat this section instead as an instance of implied polyrhythm.

14 Les 6 métronomes doivent être absolument synchronisés (ou bien dispositif électronique)
 1 baguette molle pour favoriser les graves et 1 baguette dure pour les peaux aigues
 ♩ = 120 MM Rythme de référence

The image shows a musical score for six percussionists, labeled A through F. The score is written on six staves. Above the staves, there are instructions in French: "Les 6 métronomes doivent être absolument synchronisés (ou bien dispositif électronique)", "1 baguette molle pour favoriser les graves et 1 baguette dure pour les peaux aigues", and "♩ = 120 MM Rythme de référence". A box labeled "195" is located at the top right of the score. On the left side, there is a vertical label "Peaux aigues". On the right side, there is another box labeled "195". The score itself consists of rhythmic notation on six staves, with various note values and rests. There are also some markings like "ff" and "mf" on the staves.

Figure 7.1: Persephassa

The above excerpt starts on m. 191 of *Persephassa*, where Xenakis calls for each

13 Hofmann, Boris. "Spectral Aspects In Xenakis' Instrumental Works.", Technical University of Berlin, Institut für Sprache und Kommunikation, 2005.

performer to use a metronome to achieve the required polytemporal accuracy. The initial figure once again sees all six performers in complete synchrony, with all parts calling for fortissimo quarter notes played on every quarter note beat of the 2/2 measure. The initial tempo of $\text{♩} = 40$ lasts only two measures before players D, E, and F increase their metronomes to $\text{♩} = 42$. At this point the three players start to slowly drift away from the other three who remain at the original tempo, creating a subtle but noticeable effect. At m. 195 Player B moves to $\text{♩} = 58$, pulling even further away from the two players who remain at the original tempo. This temporal shift continues to m. 200 where the six tempos form a ratio of 19:20:21:29:37:39¹⁴. At m. 205 the performers all 'swap' tempos with each other before entering a development section which sees the simplicity of the straight quarter notes replaced by fast, syncopated rhythms. At m. 215 all six players come together at half note = 60 to play three measures of quintuplet patterns before taceting and then diving back into the same polyrhythmic structure. The piece explores several more shifts between a common tempo and polytemporality, all the while increasing the density and complexity of the individual parts before settling on dotted half note = 120 at m. 430. At this point the focus turns back to spatialization as each player performs an identical figure of two quarter note rolls in successive order for a duration of 10 measures, giving the audience a sense of being surrounded by a rapidly moving structure of sound before all six parts line up for one measure of what Xenakis calls a "dense cloud."¹⁵ The six players then repeat the circulating roll pattern for 7 measures before another cloud. The process repeats itself again with 3 measures and then finally 2 before the final 15-second cloud ends the piece.

Let us consider the effect that this type of spatialization has on the listener's perception of simultaneously occurring systems. Simply by sitting in a specific location within the hexagon, a listener will be physically closer to any one given performer. This ensures that each audience member has a listening experience that is different from someone across the seating area, and one most likely focused on whatever percussion part they happen to have sat near. Xenakis plays with this idea by changing the implied meter and tempo for each player throughout the piece, creating a constantly evolving atmosphere of metric and temporal dissonance. The movement of identical repeated figures around the audience further intensifies the listener's sense of location by reinforcing the idea that one's experience of the piece is affected by their location within the seating area.

Perhaps at this point it is appropriate to look back and consider the different approaches to rhythmic and metric interplay that we have examined. Polyrythm, polymeter, and polytempo are clearly distinguished from one another in terms of conceptual approach; however, as we have observed throughout this paper, it is often possible to view an example of rhythmic incongruity through the lens of more than one of these techniques. The first excerpt from *Persephassa*, for example, is written out as an implied polyrythm, though from the perspective of someone not looking at the score it could just as well be an example of polytempo. In either case, the audible result is the same. We can say, then, that although one technique may be better suited to accomplish a specific effect than another, the same rhythmic incongruity can often be achieved through more than one approach. In keeping with this examination, let us briefly look back at how each of these three composers employed these techniques in his work.

14 Harley, James. *Xenakis: His Life in Music*. New York: Routledge, 2004. 61.

15 Xenakis, I. *Persephassa: Pour Six Percussionistes*. Salabert, 1970.

In *Drumming*, Steve Reich employs his phasing technique to shift the downbeat of a pattern to a different location within a measure. This essentially changes the position of the downbeat for one player in relation to the rest of the ensemble, however, it does not place any one player in a meter different from the rest of the group. If we focus on the position of the downbeat we see that the effect is essentially a displacement of one line relative to the others. Although this is not an example of polymeter, the effect of displacing one pattern relative to the rest of the ensemble through phasing is not unlike gradually distributing the duration of one extra note value over the course of several measures. In other words, the same displacement could be achieved through adding in one measure of a different meter, at which point the pattern would have been shifted over by the difference between the artificial meter and the established one. In a sense, then, we can say that Reich's technique has the effect of simulating polymeter. Combined with his polytemporal phasing technique, we can conclude that Reich is approaching rhythmic dissonance from more than one capacity – even if indirectly.

In the case of Frank Zappa, we see clear examples of rhythmic dissonance being used in highly visible contexts. Even if we choose to disagree with Steve Vai's transcription of Zappa's guitar solo on *Gee, I Like Your Pants* it is clear that polyrhythms are an improvisational focal point for Zappa. In both *Toads Of The Short Forest* and *A Pound For A Brown On The Bus* Zappa makes explicit use of polymeter to create a sense of rhythmic dissonance. In *Toads Of The Short Forest* the effect is clearly intended to be at the center of the audience's attention, with Zappa even taking to the microphone to describe the metric arrangement. In *A Pound For A Brown On The Bus* the effect is still present but more so in a supporting role, with the 3/4 + 4/4 melodic line serving as the musical focus and the 7/8 ostinato adding a more subtle layer of rhythmic interest underneath. In both *Toads Of The Short Forest* and *A Pound For A Brown On The Bus*, though, it is interesting to note that Zappa chooses to not only include multiple meters but also multiple tacti, with both the quarter note and the eighth note serving as the basic pulses.

In Iannis Xenakis' *Persephassa* there are certainly other considerations besides the incorporation of rhythmic dissonance - spatialization and his concept of sound clouds among them – but it is hard to ignore the mathematical precision with which he navigates the three techniques discussed in this paper. From the hypermetric polyrhythm introduced at m. 62 to the Xenakis' call for metronomically accurate polytempo at m. 191, the entire piece is a meticulously constructed and beautifully complex showcase for the potential of rhythmic interplay. The complicated rhythmic structure, combined with the hexagonal layout of the performers relative to the audience, presents the audience with an immersive listening experience.

Reich, Zappa, and Xenakis may at first glance seem like unlikely candidates for a discussion comparing compositional technique, however, as we have seen through an analysis of their work, their explorations in polyrhythm, polymeter, and polytempo connect them in a significant way. Though these three composers approach the issue of creating interesting music with techniques of irregular tempo, meter, and rhythm through radically different courses, the common goal of using these dissonances to both increase the effectiveness of a piece and challenge conventional notions of meter and rhythm in music are shared.

In an attempt to join the likes of Reich, Zappa, and Xenakis in their use of metric and rhythmic incongruity, I have employed several of these techniques in the composition of my capstone thesis MFA project, *LAVA GLASS* (2013-14). Polymetric relationships between

different parts occur in almost every movement but are especially relevant in the third movement, where vertical alignment between the four drum parts is used as a compositional decision-making tool. In this movement performers gradually introduce repeated patterns set in implied meters of 5/8, 7/8, 9/8, and 12/8 through an additive process that begins with a single low note for each player. Each time a moment of significant alignment occurs between the four drum parts (significance is determined by a changing set of criteria as more material is introduced), a new event is added to one of the drum parts. Each event can consist of the addition of a new note into the pattern or a change in dynamic or gesture. As the piece progresses and each player fully introduces his or her pattern, the rate at which these events occur becomes more frequent. Throughout this process the relationship of each pattern to the other three is continuously shifting, allowing for a polymetric cycle lasting 1,260 eighth notes to take place before all four drum parts realign.

The image shows a musical score for the third movement of 'LAVA GLASS', titled 'Heat'. It begins at measure 189. The score consists of five staves. The top four staves are for Percussion (Perc.) in different implied meters: 5/8, 7/8, 9/8, and 12/8. The bottom staff is for Maracas (Mar.) in 3/8 time. The Percussion parts are highlighted with colored boxes: orange for 5/8, blue for 7/8, green for 9/8, and purple for 12/8. The Maracas part is highlighted with red boxes. The Vibraphone (Vib.) part is at the bottom, showing a few notes and rests.

Figure 8.1: LAVA GLASS, Third Movement: Heat

Another example of metric and rhythmic interplay influenced by the composers discussed in this paper is my adoption of Reich's phasing technique in the eighth and final movement of *LAVA GLASS*. The piece begins with all six percussionists performing the same four-measure rhythmic pattern together for three repeats. At measure 5 player one's pattern is displaced by one eighth-note in relation to the original pattern (which the five other percussionists are still playing). At measure 9 player one shifts over by another eighth note and player two shifts over by one eighth note, arriving at the pattern player one had been playing during the last repeated section. This process continues until all six players have shifted away from the original pattern and are now displaced by at least one eighth note in relationship to each other. The phasing approach was inspired by Reich's *Drumming* but differs in that instead of one part being displaced and the other remaining static, all six players follow a staggered eighth note progression of displacement.



Figure 9: LAVA GLASS, Eighth Movement: Shape

The sort of metric and rhythmic interplay seen in the previous two examples have the ability to take a small, simple idea and, by presenting it in a shifting context, add a layer of complexity to music. A relatively straightforward rhythmic fragment like the one above can take on new and interesting musical characteristics as it is juxtaposed against patterns in different meters and even displaced iterations of itself. The complexity of this relationship is limited only by the rhythmic intricacy of the seed patterns and the number and divisibility of simultaneously occurring meters. By treating several lines of polymetric rhythms as a composite pattern, one can generate long and rhythmically interesting patterns from very little source material.

As demonstrated in my own music as well as the works of Reich, Zappa, and Xenakis, metric and rhythmic interplay are powerful compositional tools that can be used to methodically generate complex musical material. By writing different parts in unique implied meters we can generate polymetric cycles and use them to both structure a piece and make compositional decisions regarding the introduction of new material. We can use rhythmic displacement to shift a pattern and juxtapose it against itself, obfuscating the listener's sense of the downbeat. Furthermore, we can introduce polyrhythmic and polytemporal ideas into a polymetric framework to create a truly complex musical structure. With such rich potential, we must ask ourselves why these musical concepts are not more widely explored in the context of contemporary western music. Perhaps it is a matter of habit and comfort, or perhaps it is simply a matter of introducing the study of rhythm and meter in our music theory classrooms on the same level as harmony and counterpoint. If the latter is true, then I hope that with the canonization of more and more polymetric works into the established repertoire of western art music this subject will eventually receive greater attention.

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