# Analogy, Homology, and Rhythmic Phylogeny: Commentary on Adrian Poole's "Comparing Timeline Rhythms in Pygmy and Bushmen Music"

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ABSTRACT: In his article "Comparing Timeline Rhythms in Pygmy and Bushmen Music," Adrian Poole uses computational phylogenetic analysis to assess the similarity between canonical rhythmic patterns from two African musical cultures. He then uses these analyses to evaluate previous claims of a common origin for their (now) distinct musical practices. Poole was unable to find clear evidence of a common origin, and here I provide additional analyses of these timelines casting further doubt on such claims. Instead, I offer a perspective from convergent evolution/sociobiology which can account for the broad similarities that exist between these two sets of timelines. I conclude with a critique of the claim of Poole and others that African timelines and the musical cultures in which they appear are especially resistant to change.

IN evolutionary biology, a crucial distinction is made between structures that are analogous versus those that are homologous. Birds and bats both have wings, but these analogous structures are not based on a common winged ancestor. Rather, they are a product of convergent evolution—in this case, the development of body structures that enabled flight. The broader and more general selection pressures on flying creatures (the need for an adequate strength-to-weight ratio, the need for wings to provide lift, etc.) give rise to the structural similarities between birds and bats and their wings. By contrast, the forelimbs of humans, dogs, and whales all share the same underlying bone structure (all three have homologs for the radius, ulna, carpal bones and phalanges), as all three have common mammalian origins. Yet their forelimbs do radically different things—humans reach and grasp, dogs walk, and whales swim.

The moral of the analogy vs. homology story is clear: just because two things have a similar form does not mean they have a common ancestor, and likewise, just because two things have different forms does not mean they lack a common ancestor. The structures we see in biology are the product of both an organism's genotype and the environmental conditions that influence its phenotypic expression—and this expression is subject to (potentially changing) selection pressures in each successive generation. Moreover, in current evolutionary biology, one has recourse to direct observation of the genotype: sequence the DNA of the two organisms under consideration and see if there are matches in the appropriate chromosomal locations. If so, a strong argument can be made for homology, whether or not the phenotypes are analogous.

In his article Adrian Poole investigates long-standing claims that Pygmy and Bushmen rhythmic timelines are structurally interrelated, and (may) have a common ancestor. Poole uses edit distances between binary representations of these timelines as a measure of their similarity, which he sums up in a phylogenetic tree diagram (his Figure 4). While it is the stock and trade of musicologists of all sorts to find connections (overt and covert) within and between musical traditions, I want to raise several notes of caution regarding the claims of Poole (and others) regarding the relationship between Pygmy and Bushmen rhythms. While some of these notes are related to the nuts and bolts of Poole's representations and comparisons, others are sounded on a broader level.

I will start with the methodology Poole uses to compare timelines.  Like others (e.g., Forth, 2012, Toussaint, 2013), he uses edit distance between binary representations of timelines.  So, for example, here are three rhythms based on a cycle of 12 pulses:

> (a) 100 101 100 011
> (b) 100 101 010 011
> (c) 101 111 101 111

Swapping the note vs. rest in just two positions (marked in red) transforms (a) into (b), whereas four swaps (marked in blue) are required to transform (a) into (c).  But on a higher level, while (a) and (c) are unsyncopated patterns, (b) is highly syncopated, with failures of event binding from beat 2 to 3 and 3 to 4 (see Huron, 2006 re: event binding as a measure of syncopation).  That is, the binary representations Poole uses ignore metric structure, and indeed, the metrical structure and contexts for timelines in his corpus receive little discussion.  With three exceptions (noted below), all of the timelines are based on 4-beat metrical cycles, though in some cases there are double cycles (i.e., 24 and 32 pulse cycles).  Thus while the beats may be subdivided into triplets or quadruplets, the four-beat meter provides an essential framework for almost all of these timelines.  As Agawu (2006) has pointed out, the varying metrical interpretations of the "standard pattern" (2212221—Poole's timeline no. 2) used in many different African musical genres and traditions illustrates the importance of meter.  While unenculturated listeners are apt to regard this timeline in a six (or three) beat meter (|x.|x.|xx|.x|.x|.x|) enculturated listeners hear it as |x.x|.xx|.x.|x.x|.  In these different metrical contexts, the "same" timeline becomes two rather different rhythmic/perceptual objects.

Thus rather than simply looking at binary sequences in isolation, one should look at them in their metrical context, and thus the "base enzymes" of each timeline should be coded in a way that indicates their metrical orientation.  To illustrate, I will focus on the triple pulse meters in Poole's data set.  For starters, there are 8 possible "metric feet" in triple-pulse meters (here 1 = articulation/stroke, while 0 = a silence):

> 100 (a), 010 (b), 001 (c)
> 110 (d), 101 (e), 011 (f)
> ~~111~~ (g)
> 000 (h)

The color coding highlights a key difference amongst the various metric feet: those that have an onbeat element (black) versus those that do not (red).  The "000" sequence (in blue) indicates a beat where there are no articulations whatsoever—hence it is different from off-beat elements (b), (c), and (f) which can give rise to syncopated patterns.  In Poole's corpus there are never more than two consecutive strokes (i.e., there are no interval vectors with consecutive "1s"), and thus the three-stroke foot (g) does not occur in any of the Poole's timelines.  Moreover, there are also constraints on the concatenation of metric feet; for example (f) cannot be followed by (a), (d), or (e), but for the sake of brevity I will not consider concatenation constraints any further here.

Indeed, it is clear that timelines are organized according to two general constraints.  The first is that of rhythmic density: relative to the cardinality the cycle (Poole's pulse index, "p" in his Table 1), no more than half (or half +1) of the pulses in a cycle are ever articulated by the timeline. This is another aspect of Arom's principle of rhythmic oddity (Arom 1991).  The second is that of maximal evenness, as discussed by Benadon (2007), Toussaint (2013) and London (2012), and as acknowledged by Poole.  Given *m* number of articulations in a cycle of *p* total pulses, maximal evenness requires the "largest possible temporal distance" between each and every element in a rhythmic pattern.  So, in a metric cycle of 12 pulses, a maximally even rhythm of 4 elements would simply be 3333.  However, if one were to have a 5 element rhythm in the same metric framework, one cannot divide 5 into 12 without a remainder, nor can one have "half pulse" units. There are five maximally even 5-element patterns in a 12 pulse cycle: 32322, 23223 (Poole's timeline no. 7), 32232, 22323 (Poole's timeline no. 6), and 23232 (N.B., for a further discussion of maximal evenness, and why some maximally even 12-pulse patterns are more likely than others, see London (2012), pp. 155-160).

Let me now redraw part of Poole's Table 1 in slightly different way, looking first at the timelines in triple-pulse meters with 12 or fewer pulses:

Table 1. Metric "feet" in Poole's triple pulse timelines; 100 = (a), 010 = (b), 001 = (c), 110 = (d), 101 = (e), 011 = (f), and 000 = (h).  Color coding indicates onbeat (black) or offbeat (red) feet.

| No. | Group | Vector | Rhythm | Foot Pattern | Comment |
|---|---|---|---|---|---|
| 3 | BaYaka | 222222 | x.x\|.x.\|x.x\|.x.\| | e – b – e – b | Repeated half measure |
| 1 | BaYaka | 2221221 | x.x\|.x.\|xx.\|x.x | e – b – d – e | |
| 8 | BaYaka | 222123 | x.x\|.x.\|xx.\|x.. | e – b – d – a | = 1 without last element |
| 9 | BaYaka | 222213 | x.x\|.x.\|x.x\|x.. | e – b – e – a | = 8 w/5th element shifted |
| 2 | BaYaka | 2212221 | x.x\|.xx\|.x.\|x.x | e – f – b – e | 3d beat un-articulated |
| 7 | BaYaka | 23223 | x.x\|..x\|.x.\|x.. | e – c – b – a | |
| 6 | BaYaka | 22323 | x.x\|.x.\|.x.\|x.. | e – b – b – a | |
| 20 | San | 222222 | x.x\|.x.\|x.x\|.x. | e – b – e – b | = no. 3 |
| 21 | San | 24222 | x.x\|...\|x.x\|.x. | e – h – e – b | = no. 3 w/ empty 2nd beat |
| 25 | San | 3324 | x..\|x..\|x.x\|... | a – a – e – h | Second beat onbeat |
| 22 | San | 234 | x.x\|..x\|... | e – c – h | Three-beat meter |
| 23 | San | 243 | x.x\|...\|x.. | e – h – a | Three-beat meter |
| 24 | San | 2223 | x.x\|.x.\|x.. | e – b – a | Three-beat meter |

This metrically-sensitive approach allows one to note a number of important similarities and differences between the Pygmy and Bushmen timelines.  All of the timelines (save for no. 25) start with the (e) onbeat foot.  All of the BaYaka timelines all have an offbeat foot on the the second beat, usually (b), and all save no. 3 have an onbeat foot on the fourth beat.  One could thus summarize by saying the master pattern for the BaYaka timelines is: "e – b – X – a," where "X" is most variable element.  Regarding the "X" element, there are two distinct groups of BaYaka timelines, those that have an onbeat foot on beat 3 (symmetrically dividing the measure), versus those that do not, (i.e., timelines 2, 6, and 7); note that this grouping is not evident in Poole's phylogenetic tree diagram (see his Figure 4b).  This is due, I suspect, due to the differences in number of elements amongst the timelines, which drives his separation between timelines 1, 8, and 9, even though their onbeat/offbeat structure and opening feet are the same.

        The San timelines are more of a motley, as they differ both in overall metric structure (20, 21, and 25 are four-beat patterns, while 22, 23, and 24 are three-beat patterns), onbeat/offbeat articulation, and (unlike the BaYaka timelines) often have an "empty" beat (marked in blue in Table 1).  Likewise, the San have no patterns which involve "1s"; overall they are less dense than the BaYaka timelines.

        The 24 pulse BaYaka timelines present a different issue for similarity measures, namely those related to embedding.  These timelines are given in Table 2:

Table 2. 24-pulse BaYaka timelines, with metric feet analysis (same sigla and color coding as in Table 1).

| No. | Vector | Foot Pattern | Comment |
|---|---|---|---|
| 5 | 223221\|223212 | e – b – b – e \| e – b – b – d | Double version of nos. 6/7 |
| 13 | 222222\|1222212 | e – b – e – b \| d – e – b – d | 1st 4 beats = no. 3 |
| 4 | 22223222223 | e – b – e – c \| b – e – b – a | 1st measure parallel to nos. 3/9 |
| 10 | 2222122222212 | e – b – e – e \| b – e – b – d | |
| 11 | 2222212222212 | e – b – e – f \| b – e – b – d | |
| 12 | 2222212222221 | e – b – e – f \| b – e – b – e | |
| 14 | 2221222122222 | e – b – d – e \| f – b – e – b | Onbeat foot at beat 7 |

The structure of these 8-beat timelines can be viewed in most cases as extensions of a 4-beat timeline. Timelines 13, 4, 10, 11, and 12 begin with complete or near-complete embeddings of timeline 3.  The last 4 beats of these metric cycles are noteworthy for being "offbeat-onbeat-offbeat-onbeat", the opposite of timeline 3.  As noted in Table 2, if the first four beats are generalized as "e – b – e – X" (similar to the master pattern for the four-beat BaYaka Timelines given above), then the generic pattern for beats 5-8 would be "b – e – b – X."  There are important differences among these timelines as well: nos. 5 and 13 contain onbeat feet at beat 5, creating a symmetrical articulation of the 8-beat cycle.  Likewise, no. 14 has both an offbeat on beat 5 and an onbeat on beat 7, a unique feature amongst these timelines.  These similarities and differences are not evident in Poole's Figure 4b, nor are the embedding relationships at all evident.

To summarize, the BaYaka triple pulse timelines show a coherent set of similarities, as a "master pattern" is evident for both their 4- and 8-beat versions, with a clear set of family relationships among them. The San triple pulse timelines do not exhibit the same degree of internal similarity, though one should also take note of their much smaller sample size (aside from timeline no. 20, Poole has only single samples of the other San timelines). None of the San timelines show any strong similarity to the master pattern found in the BaYaka timelines. Quite the opposite: the San timelines have different patterns of on and offbeat organization, are generally less dense, and involve both three- and four-beat meters.

In short, the BaYaka and San timelines simply aren't that similar when examined in their metrical contexts. Moreover, unlike physical anthropologists, we have no recourse to the "Mitochondrial DNA" of these timelines and the musical cultures form which they came. All we have are a collection of current Phenotypes, whose similarities and differences we can observe. How then to account for the similarities that Poole found in his analysis? I believe that his findings—especially with regard to the presence of a "222" rhythmic sub-sequence found in many of the timelines (what he refers to as a "seed" rhythm) are due to the generic constraints noted above: a limit on the relative density of events per cycle, combined with maximal evenness, will necessarily generate 222 sub-sequences, especially in rhythmic/metric cycles of 12 or more pulses. In short, the few similarities that may be observed between BaYaka and San timelines are due to analogy, not homology, as the "selection pressures" of moderate density and maximal evenness constrain the "evolution" of these rhythms in a convergent fashion.

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The biggest and most troubling problem with Poole's argument, however, is not its similarity metric or timeline representation, but its assumption that African musical culture and practice has remained more or less static over the last 70,000-100,000 years. This claim (which, admittedly, is more from Grauer and Kubik than from Poole) rests on huge assumptions regarding the stability of technology, locale, language, cultural practice, etc. To make a similar claim in western musical practice would be unthinkable, given what we know of changing musical practice of even a small sub-genre of western music. And this is true even though (at least for some western traditions) there are technologies of notation, instrument-making and pedagogical institutions which have slowed and/or constrained the rate and direction of musical evolution—though of course some of those technologies also fostered rapid change and evolution. In short, we simply have <u>no idea whatsoever</u> what kinds of rhythms were performed, danced to, sung, etc. by the forebears of 20th and 21st century Pygmy and Bushmen musicians even a few hundred years ago, let alone thousands. Rhythmic practices can (and probably did) change many times over this vast time frame, perhaps in relation to language evolution (Hannon, 2009; Kelly, 1989; Patel, 2006), technological advances which could influence the construction of drums and other instruments, population migration, interactions with other cultures (both within and beyond the African continent, c.f. the broad reach of the Malian and Songhai empires), and so on. To ascribe some sort of biologically-determined rhythmic essentialism to the musical practices of these African musicians (given the author's use of Kubik's and Grauer's theories and comments on p. 173 and 185-186 what else can it be?) invokes ideas of primitivism, naturalism, and authenticity that have been debunked long ago.

This, then, is the real problem with "phylogenetic analyses" of music such as those suggested by Poole: they make untenable assumptions about the historical fixity of cultural practices. This is especially problematic when applied to the music of Third World indigenous cultures by First World American/European researchers.

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## NOTES

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