WIDE-SENSE CLAVE: TOWARDS A TRANS-DIASPORIC RHYTHMIC GRAMMAR

by

REILLY GAULT

A THESIS

Presented to the Department of Jazz Studies
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Arts

December 2025

An Abstract of the Thesis of

Reilly Gault for the degree of Bachelor of Arts
in the Department of Jazz Studies to be taken December 2025

Title: Wide-Sense Clave: Towards a Trans-Diasporic Rhythmic Grammar

Approved: *Dr. Juan Eduardo Wolf*
Primary Thesis Advisor

This thesis begins to develop a systematic cross-cultural framework for wide-sense clave, proposing that the rhythmic organizing principles most famously found in Cuban tradition are in fact only a single manifestation of a deeper concept shared across Afro-Diasporic musical traditions. Building on prior scholarship, the project argues that clave should be understood not simply as a regionally bound pattern but as a trans-diasporic logic for evaluating rhythmic alignment, orientation, and structural coherence. In part, this thesis is a proposed answer to Lehmann's request for a "hierarchical…contour…for the short-range directionality of the clave/timeline period." (Lehmann, 2002: 71) The first part of the thesis critiques Toussaint's pulse-saliency approach to quantifying meter in African music, resulting in a corrected statistical analysis that accounts for clave direction, revealing consistent hierarchical syntactic weights across traditional timeline patterns from around the African Diaspora. These weightings form the basis of an analytical methodology capable of systematically classifying rhythms, identifying clave-neutral or clave-ambiguous rhythms, and potentially extending clave analysis beyond typical 16 and 12 pulse rhythmic cycles. This thesis will also propose future avenues of research, with particular attention to methodological approaches that may account for clave as a harmonically emergent phenomenon. The latter two sections of this thesis translate this framework into public-facing and performance-based forms: the beginnings of a comprehensive online rhythm repository designed to make clave concepts accessible to musicians and non-musicians globally, and a senior recital demonstrating wide-sense clave across traditions from Cuba, the Dominican Republic, Bolivia, Guinea, Brazil, and multiple regions of Ghana.

Acknowledgements

I would like to express my gratitude to Dr. Juan Eduardo Wolf, whose patience was only exceeded by his willingness to discuss my theories, entertain my increasingly bold claims about the mathematical structure of rhythm, and then play some bomba. I am likewise grateful to my CHC Representative and advisor, Carol Stabile, for helping me navigate through the CHC and always being so supportive and excited about my progress. I am indebted to the wonderful jazz faculty at the University of Oregon, whose flexibility and belief in my niche allowed me to pursue one petition-heavy rollercoaster of an undergraduate education. I am likewise indebted to the Stamps Scholars foundation, who funded my schooling and my research in Ghana. I am deeply grateful to all the musicians, masters, and teachers that I have learned through and from over the years, whose playing inspired my obsession with rhythm long before this project had even been thought of. To the Good Fight and University Fellowship Church, thank you for always pointing me to Christ; the only one who truly lived *en clave*, died in my place, and was resurrected to give me new life. Thank you for always reminding me what and who music, math, and clave, ultimately point to. Thanks to all my friends who have endured years of clave demonstrations, unsolicited rhythm explanations, showcases, and comparisons, the sounds of drumming coming from my room at all times of day, and my countless “wait, play this rhythm really quick” moments. To my family, thank you for encouraging me throughout this whole process. Thank you for starting me on my unique musical journey. Thank you for always cheering me on, bolstering me in my unproductive days, and trusting me when I said that I was writing a thesis about “hyperdimensional record players.”

Reilly Gault
Eugene, Oregon, Fall 2025

Table of Contents

List of Figures

Chapter 1: Stumbling Across Clave in Ghana

It was July 20th, 2023. I was in Accra, Ghana, learning Ewe drumming from one of my masters, Gasco Atsu Ablordey, whom I had just recently met. We were sitting nearby the Performance Studies area of the University of Ghana in Legon, each of us manning an *atswereshi* drum. On this day in particular, Gasco was helping me learn the famed Ewe piece known as *Gahu*. He would play a phrase on an instrument, and I would repeat it until I could play it accurately without his help. The phrases started off as simple and became increasingly complex as we moved from the supporting instruments to the lead drum. All of this initial learning was done in isolation from other instruments; there was no bell or rattle that I could use as a time referent. I was stuck with only the phrases that I was given, seemingly in a vacuum.

A few days later, the second time I met with Gasco, he had brought with him another student around my age, from the University of Ghana, who had agreed (willingly or unwillingly) to play a bell pattern for the duration of my lesson. To my joy, and Gasco's surprise, I managed to play all the lead drum phrases and variations in the correct alignment with the bell phrase, on the first try. This is something that is notoriously difficult for foreigners to achieve, and Gasco's reaction reflected that humorously. After that moment, he began to affectionately refer to me by the nickname "International Drummer!" I was initially shocked by his response, it didn't seem like much of a difficulty to me. The relationship between the interlocking lead drum and bell phrases felt intuitive and natural to me; in fact, I didn't give it much thought at the time, my hands just began to move when I felt they needed to.

After working on Gahu, we moved to other pieces like *Atsiagbekor* and *Borborbor*, which I picked up just as easily, receiving more praise and excitement from my master each time. One day Gasco brought five others with him (as witnesses, I later found out), sat me down, and told me that he wanted to teach me something very difficult. "*Agbadza*," he explained, "is a rhythm that is very difficult, even for natives to learn." At the University of Ghana, they teach a 'watered-down' version of *Agbadza* to the students over a period of three months. Then, looking me directly in the eyes, he said, "I want to teach you the real *Agbadza*, the indigenous *Agbadza*." I shuddered with excitement and anticipation at this honor and challenge, it seemed I even had an audience!

This time, we started with the bell pattern already playing, and Gasco played a lead drum phrase on the *sogo* that I tried my best to imitate. At first, it caught me off guard, it was oriented in a way that I didn't expect, but once I got used to it, it aligned perfectly with my already present intuitions. Gasco beamed with glee and those watching cheered with surprise and excitement and began dancing *Agbadza*. After a few more lessons specifically on *Agbadza*, Gasco honored me further by inviting me to perform *Agbadza* with his cultural troupe at two Ewe funerals, with me playing *sogo*, the lead drum.

The reason I share this is not to show my own musical prowess, but to highlight how something deeply ingrained in my musical intuition enabled me to pick up these difficult rhythms and phrase relationships with ease. This instinct, as I later found out, came from my enculturation in *clave-based music*.

At the time, I happened to be reading a paper by Mehmet Verkaç titled *A Cross-Cultural Grammar for Temporal Harmony in Afro-Latin Musics: Clave, Partido-Alto and Other Timelines*. I came across this quote:

> Identifying clave direction is a challenging task for anyone who has not been raised with clave–based music, and sometimes even for those who have. Moreover, those who have been "raised with clave" often find it difficult to explain why clave works the way it does. It is not uncommon to hear that "it's in the blood." However, given the current scientific understanding of the interaction

> of nature and nurture, it is far more likely that clave is a rational principle that can be described in a quantitative manner. (Vurkaç 2013: 49)

I grew up listening to a wide variety of Caribbean music, and I started seriously learning to play it late in High School. Unbeknownst to me, this early engagement had already started structuring my musical intuition around clave-based music. I never would have imagined that all the years of listening to music, learning different rhythms, clapping along to salsa, and slowing down YouTube videos would start to embed me in a sense of temporal grammar that I would candidly encounter in Africa.

When I read Vurkaç's quote, the phrase "it's in the blood" resonated immediately. Musicians in both Latin and West African traditions commonly explain their musical fluency as something innate or ineffable. Yet my own experience contradicts that narrative. I had not been raised within an Ewe community; I had no cultural lineage tying me directly to Agbadza; and yet, the logic of the interlocking patterns felt immediately understandable to me.

I also brought with me on my trip Godfried Toussaint's book The Geometry of Musical Rhythm: What Makes a "Good" Rhythm Good? In this book, which will be discussed in further detail later, Toussaint employs numerous mathematical methodologies to attempt quantifying various musical phenomena pertaining to rhythm. At some point after reading Vurkaç's paper, and continuing with my musical endeavors in Accra, I read chapter 18 of Toussaint's book, and I found something that shocked me. Toussaint attempted to make a pulse-saliency analysis of select Afro Diasporic timelines: a histogram intended to show which rhythmic positions are the most salient among timeline patterns, or which pulses function as strong anchors. But when I worked through his data set, I found a significant oversight with major implications. About half of the timelines that he included in his comparative set were oriented backwards relative to the others. This effectively flipped their apparent saliency and produced a misleading cross-pattern comparison. In other words, his histogram was comparing some patterns that were head-first, and others that were tail-first. The results mixed two incompatible directions and produced false symmetries. That mistake mattered. Toussaint was trying to understand the intuitions of musicians in a quantitative way, but his starting point in that analysis failed to even incorporate the intuitions he was striving to quantify!

After my initial shock, this mistake became an inspiration and compass for my subsequent work. It suggested a very concrete starting place: fix the orientation problem, expand the database, formalize a consistent way to measure pulse saliency while recognizing timeline directionality, and then test whether this model aligned with performers intuitions, including my own.

By August 29th, 2023, those corrections and additional ideas had coalesced into a working model. I sketched my framework in a notebook and quickly validated it against all the Ewe pieces I had learned with Gasco, and all the Ga and Akan pieces I had learned with one of my other masters, Daniel Brown. My model matched my own, and my masters, musical intuitions perfectly! A couple weeks later, when I moved north to Tamale to study Dagbani drumming, I tested the model again, in a completely new musical environment. Once more the model perfectly matched my own intuitions, as well as the intuitions of my masters. That moment was when I realized that what I had stumbled upon was not just a possible explanation for my isolated experiences in Accra, but the beginnings of a possible broader framework, a way to formalize something that musicians have been describing as “natural,” “intuitive,” or “in the blood” for generations.

The rest of this thesis emerges from that realization. Before presenting the model itself, it is necessary to clarify relevant foundational concepts. The following section introduces the definitions, terminology, and theoretical assumptions that comprise the proposition itself.

Chapter 2: What is clave?

According to Kevin Moore, clave has a reputation of being one of the "most infamously confusing topics in all of music." (Moore, 2011: 12) In his dedicated book Understanding Clave and Clave Changes, Moore seeks to demystify the concept of clave as it pertains specifically to Cuban tradition. David Peñalosa, in his books The Clave Matrix and Rumba Quinto, likewise makes a significant contribution to understanding Cuban clave in popular and traditional contexts. Because the relevant popular discourse has been largely publicized strictly in the Cuban context, I have elected to adopt much of the terminology that Moore and Peñalosa use, for the sake of clarity and consistency.

Given the diversity of meanings attributed to the word clave, it is important to define precisely how I will use the term in this thesis. The following definitions from Vurkaç help begin to lay this out:

> The word "clave" has several meanings, so it is important to specify which I am addressing here. Three of these meanings are well–known: (1) claves, the instrument; (2) clave in the harmonic sense, as in "the key of C major" (in Spanish); and (3) a small family of patterns, which is what musicians typically have in mind for clave. (Vurkaç 2013: 38)

A fourth category that I would like to define is what I will refer to in this thesis as Cuban clave. Lehmann offers a helpful definition: "[Cuban] clave operates as a sort of "deep structure" of melo-rhythmic organization within the psychological, cognitive and aesthetic reality of Cuban music." (Lehmann 2002: 11) This specific definition and understanding of clave is what authors like Peñalosa and Moore have primarily focused on.

The fifth and final category that I propose is what Vurkaç refers to as "clave direction" and "wide-sense clave," Lehmann refers to as "a certain structural rhythmic universality or essence," and Fiol refers to as "the hidden rhythm." Vurkaç offers a very clear explanation of this broader concept:

> Clave direction is a concept and a rhythmic–regulative principle. It is analogous to the key of a piece of music, but instead of governing tonality, it governs fine–scale local timing… Clave direction gives a composer or improviser a set of preferred timing options and the appropriate places within each phrase to place them…along with acceptable ways to break these rules… Just as the key determines the tonal center of the piece, the clave direction is the overarching determinant of the timing preferences for the piece, but like its tonal counterpart, it allows for variety in musical expression, and even tricks, puzzles and multi–layered playfulness in its execution. In order to make the most artistic and culturally sensitive use of this principle, I offer an approach to understanding clave direction that I call wide–sense clave. In this wider sense, clave–the–concept denotes not just the existence of specific patterns, but the relationships that any pattern may have with a family of associated patterns. [emphasis mine] (Vurkaç 2013: 38)

Fiol reflects upon a profound realization of this reality, similar to my own in his anecdote:

> …my Afro-Cuban background allowed me to converse with them [master drummers] in a musical tongue far more ancient and profound than any bits of speech we could have exchanged. That language, the hidden rhythm uniting West Africa's musics with those fashioned in its Diaspora, is called clave in Cuba. My already developed knowledge of the clave's underlying structure made it possible to intuit the best way to riff atop Olatunji's masterful rhythmic bed. In that moment of near familial recognition, when I felt us all in some kind of zone, I began to understand how intimately Afro-Diasporic music has always remained connected to the "Motherland." [emphasis mine] (Fiol 2007: 1)

Lehmann articulates his own understanding of this phenomenon:

> …a deep-structural grammar of 'clave' has perhaps more cognitive salience, and thus analytic-theoretical relevance, than usually recognized. I propose that such a grammar can apply to musical situations beyond the particular context of Cuban musical expression, and to idioms without an externalized timeline… 'clave' – rather than being just one equal component in a polyphonic musical texture – is experienced as a fundamental, internal structural dynamism, which for the enculturated listener and performer imbues the music with a particular kinetic energy and contrapuntal organization, extending into both temporal and tonal dimensions…the notion of a 'clave' as an African cognitive construct or "belief" points beyond its particular conceptualization in Cuban culture. 'Clave', I assert, has important theoretical implications to the body of African musical practices in general… [emphasis mine] (Lehmann 2002: 12)

Unless specified otherwise, this broad structural meaning is how I use the term clave in this thesis. The main idea is that there is a shared "hidden rhythm," a "cognitive construct," a "contrapuntal organization" that exists in a wider sphere of Afro-Diasporic musical tradition, with Cuba representing only one instantiation of this broader phenomenon. Clave isn't a merely surface level abstraction or outside concept being imposed onto African music. It has to do with the very DNA of how Afro-Diasporic music is organized and generated. Furthermore, as Lehmann notes, "if the ubiquity of this structural phenomenon as one of the most enduring Africanisms in the music of many traditions in the diaspora may be taken as an indicator, we may be justified attributing more than superficial significance to its presence." (Lehmann 2002: 22)

For this reason, it is especially important to make certain that the distinction between Cuban clave and wide-sense-clave is understood by the reader. The claim here is not that a "Cuban-centric" manifestation of clave and clave concepts should be imposed on the rest of the diaspora. Indeed, no one cultural manifestation should be seen as prescriptive of the whole. Rather, the claim is that there exists a shared structural principle that manifests uniquely in different cultures but remains ubiquitous at the level of temporal organization. The use of Cuban terminology to describe this trans-national phenomenon should not be confused with a claim of "Cuban-centrality." (Lehmann 2002: 143)

With the conceptual ground laid, we can now turn to an analogy that lays out clave in a more intuitive sense and touches on the concept of clave direction. I refer to this illustration as my "hyper-dimensional record player."

Clave Analogies

Imagine that you have a record player that allows you to vertically stack vinyl records, such that each record is spinning at the same rate, and the hyperdimensional stylus is making contact with each record in the same location simultaneously. Now imagine that each vinyl contains a recording of a single percussion instrument, playing an unchanging rhythmic pattern that repeats with each revolution of the record. If there are five records being played at once, and they all contain differing instruments and rhythms, the sounding result should be some sort of composite rhythm sounded by a seeming ensemble of five different musical voices. Now, to alter the sound of this ensemble, you are allowed to remove one of the records of your choice, while the remaining four continue to spin and play. This is somewhat easily done, it doesn't matter too greatly which instrument you choose to remove, or when you decide to remove it. Say that you've decided to remove the top disc, and after doing so you can hear the subtle difference in the sound of the ensemble. Now, say you decide that you would like to place your vinyl back on the stack of spinning records. How can you possibly situate the record in your hands, so that, when you decide to place it back on the stack, it is aligned properly with the other records as they spin?

Upon further examination, you notice that the face of the record that you're holding is divided into two halves, one half with a red hue and the other with a blue hue. With a quick glance at the stack of still-spinning records, you now notice that, even though all the records are playing recordings of different instruments and rhythms, each has a blue tinted half and a red tinted half. You quickly realize that all the blue tinted halves are vertically aligned on the stack, as are the red tinted sides. Intuitively, you assume that if you place your record on the stack in such a way that its red and blue sides vertically align with all others, then the resulting rhythm would be aligned. With this in mind, you place your record on the stack in the proposed orientation, and it begins spinning again, with its rhythm perfectly aligned.

This is analogous to how clave-based music functions. Every asymmetrical rhythm (any rhythm that doesn't contain two equal halves) has a half, to maintain the analogy, that is colored relatively red, and a side that is colored relatively blue. In order to properly orient any such rhythms being played simultaneously, their 'red' and 'blue' sides should vertically line up with each other. In Cuban terminology, this alignment is called played en clave. If any rhythm is misaligned such that its 'blue' side is aligned with all the other 'red' sides, its alignment is said to be crossed, or cruzado. This is akin to playing out of tune, rhythmically speaking. This concept of rhythmic polarity and bisectional alignment is what's known as "clave direction" and understanding it intuitively is vital for the authentic performance of such traditions. (Vurkaç 2012: 1, Lehmann 2022: 24)

Vurkaç offers another analogy to help demystify this concept from a different angle:

> …a graphical analogy is provided below to present the idea in an alternative manner. Imagine a fictional culture in which visual decorations, no matter how elaborate, are generally arranged in a pattern of alternating round and pointy designs. Assume for the sake of argument that stars and circles have traditionally been used to provide the alternating pattern, and that the arrangement in Figure [1], line one, is called the "forward" pattern. A pattern with circles first and then stars would be "reverse." Now imagine that an artisan wishes to expand his or her options beyond stars and circles, and introduces a rhombus. However, in order to remain true to tradition, he or she must consider whether a rhombus is more or less pointy than a star or a circle. The artisan concludes that a rhombus is less pointy than a star (Figure [1], line two), but more pointy than a circle (Figure [1], line three). The artisan has managed to stay within the tradition while introducing new elements. If other shapes are introduced, the keepers of the tradition who have internalized the rules of the design idiom would intuitively recognize the direction of a new example such as those in Figure [1], lines four and five.

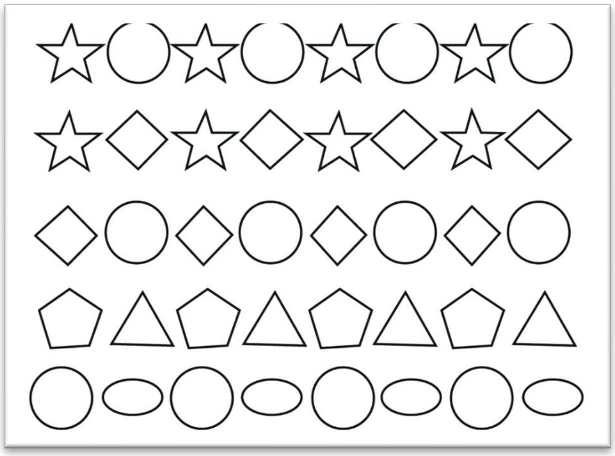

Figure 1 Vurkaç's graphical analogy for clave

For clarification, the first three lines of Figure 1 are in the "forward" direction, and lines four and five are both in the "reverse" direction. The artisan introducing new shapes recognized the triangle in line 4 as *more* pointy than the pentagon and recognized the ellipse in line 5 as *more* pointy than the circle.

Bringing this back to clave: the alternating "round" and "pointy" shapes in the analogy correspond to the red and blue halves of a vinyl disc spinning on the hyperdimensional record player. What this second analogy emphasizes is that the degree of "redness" or "blueness" is determined only in relation to the opposite half. One side isn't *absolutely* red; it is simply *more* red than the other. Likewise, the other half isn't inherently blue; it is just *more* blue than its counterpart.

In other words, clave direction, like directionality in the shape analogy, emerges from relative contrast, not from a fixed property of each half. In Cuban terminology, instead of these halves being referred to as red and blue, or round and pointy, they are called the "three side" and "two side." (Lehmann 2002: 24)

A clave cycle can be understood, in general terms, as a recurring rhythmic span whose two halves are asymmetrical. In the hyperdimensional record-player analogy, each spinning disc represents one full clave cycle. In Vurkaç's shape analogy, a clave cycle consists of one pointy shape and one round shape. The requirement of asymmetry is essential: without a meaningful contrast between the two halves, no direction can be inferred. A record that is entirely blue, or a pair of identical circles, offers no basis for comparison. This kind of perfect symmetry eliminates the possibility of directionality altogether. For the purposes of this thesis, I will only be focusing on clave cycles divided into either twelve or sixteen relatively equal subdivisions, which, borrowing from Toussaint's terminology, I will refer to as pulses. (Toussaint 2020: 104) Each of these pulses occupies a distinct position in the cycle and therefore merits a label. For the sake of clarity, I will lay out here a (largely Cuban) naming scheme for each of them that I have adopted from Moore and Peñalosa, with my own modifications and additions. (Moore 2011: 73, 2012: 77-85)

Let us begin with a 16-pulse clave cycle. Pulses are referred to in symmetric pairs; each pulse is grouped with its corresponding pulse in the opposite half of the cycle. Because our cycle is 16 pulses long, each half contains 8 paired positions. To remain consistent with Toussaint's methodology, I will number these pulses 0 to 15, with those 0 to 7 being in the first half, and those 8 to 15 being in the second half. Thus, pulse 1 (p_1) corresponds to p_9, p_2 corresponds to p_{10} and so forth. Within each pair, one pulse will be designated primary, and the other is secondary. This distinction will become much more relevant, and will be defined, when my model is presented.

Pulses p_0 and p_8 are called the *downbeats* or *frontbeats*. I will refer to these with the letter 'F.' The next pulses, p_1 and p_9 are called the *quinto* pulses, named after this pulse's prominent featuring in *quinto* phrasing in Cuban *rumba*. These will be abbreviated as 'Q.' Pulses p_2 and p_{10} are called *quemado*, *seco*, or *slap*, named after the position of the slap stroke in the common conga *marcha* pattern; I will denote them as 'S.' The pulses p_3 and p_{11} are very important. They are called *bombo*, after the bass drum on a drum kit. This pulse is critical to many Latin music genres; I will refer to them with the letter 'B.' Pulses p_4 and p_{12} are common in American music, usually known as the *backbeat,* or "two and four." These will be marked with 'K.' The following pulses p_5 and p_{13} are usually called either *bota* or *cáscara* and will be abbreviated 'C.' Pulses p_6 and p_{14} are also of vital importance; many Cuban musicians pair them with the *bombo* pulses. These pulses are called *ponche* and I will refer to them with the letter 'P.' Finally, p_7 and p_{15} are often called *platillo*, named after a common rhythmic figure in Charanga Habanera's music. I will denote these final pulses as 'O.' This is visible in Figure 2 below:

Pulse #	p_0	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}
Name	F	Q	S	B	K	C	P	O	F	Q	S	B	K	C	P	O

Figure 2 Pulses in a 16-pulse clave cycle and their names

Much of this terminology is applicable to a 12-pulse cycle as well, except that there are only six pulse pairs rather than eight. Pulses p_0 and p_6 are the *frontbeats* (F), pulses p_1 and p_7 are the *quinto* pulses (Q), pulses p_2 and p_8 are the *bombo* pulses (B), pulses p_3 and p_9 are the *backbeats* (K), pulses p_4 and p_{10} are the *ponches* (P), and pulses p_5 and p_{11} are the *platillos* (O). This 12-pulse model is shown in Figure 3 below:

Pulse #	p_0	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}
Name	F	Q	B	K	P	O	F	Q	B	K	P	O

Figure 3 Pulses in a 12-pulse clave cycle and their names

Having now established a conceptual framework and clarified terminology, we can turn to Toussaint's crucial work, and the key error that led to the development of my own model.

Chapter 3: The Problem of Counting Without Direction: Revisiting and Correcting Toussaint's Model

In Chapter 18 of *The Geometry of Musical Rhythm, Meter and Metric Complexity*, Toussaint begins by laying out four antiquated definitions of meter listed by Richard Cohn, and a fifth from G. Cooper and L. B. Meyer. (Toussaint 2020: 103) They are as follows:

1- "Beats are … grouped into a regular repeating pattern of strong and weak. This is the meter."
2- "This pattern of stressed and unstressed beats results in a sense of metrical grouping or meter."
3- "Meter provides the framework that organizes groups of beats and rhythms into larger patterns of accented and unaccented beats."
4- "Meter is the arrangement of rhythms into a pattern of strong and weak beats."
5- "Meter is the measurement of the number of pulses between more or less regularly recurring accents. Therefore, in order for meter to exist, some of the pulses in a series must be accented—marked for consciousness—relative to others."

Toussaint surmises "… the notion of regularity of beats appears to be one of the salient features in most definitions of meter." Given this understanding, Toussaint seeks to apply these concepts of meter to several questions, one of which is extremely relevant to this discussion: "the question of whether meter exists in African rhythm." (Toussaint 2020: 103) Here, Toussaint only focuses on rhythms that fit inside a 16-pulse cycle.

Toussaint uses what he terms a pulse saliency histogram to quantify meter. The method involves stacking a sample set of rhythms of equal cycle length such that their pulse positions align vertically, then counting the number of onsets, pulses that are "played" rather than rested, at each pulse position. The resulting frequencies indicate how often each pulse is activated across all included rhythms. By examining these values, Toussaint identifies which pulses occur most consistently and organizes them into a hierarchy of relative importance, a framework he calls hierarchical meter (Toussaint 2020:104). Using this approach, he presents pulse saliency histograms for several Western musical repertoires and then compares them to a histogram generated from a selection of African "asymmetric timelines" in order to explore the question of meter in African music.

As a comparative constant Toussaint introduces the theoretical General Theory of Tonal Music (GTTM) hierarchy which is as follows:

Instead of measuring frequency on the y-axis like Toussaint's other histograms do, this graph measures "metrical weight." In essence, this graph is a theoretical framework for hierarchical meter, and the y-values are simply the priorities that are associated with each pulse, and not yet the "empirically observed frequencies of occurrences." (Toussaint 2020: 107)

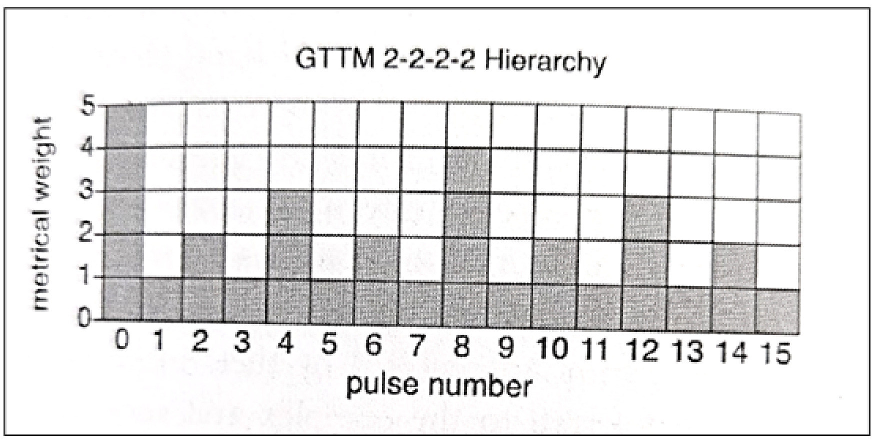

Figure 4 Generative Theory of Tonal Music metrical hierarchy

The first sample that Toussaint draws upon for a pulse saliency histogram is Palestrina's Sixteenth-Century motet, Pater Noster as compiled by Joshua Veltman. The resulting graph is shown below in Figure 5:

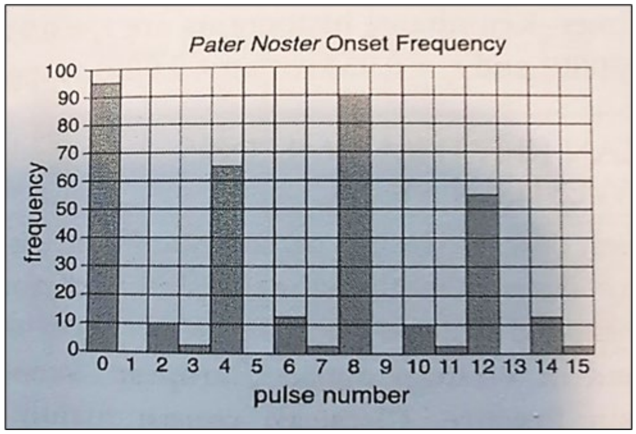

Figure 5 Pater Noster pulse saliency histogram

As Toussaint says, "The correspondence between this histogram and the GTTM hierarchy in terms of the ranks of saliencies of its pulses is visually striking." He continues by showing a histogram compiled by Palmer and Krumhansl of a large sample of Common Practice music from composers J. S. Bach, Mozart, Brahms, and Shostakovich. This is shown below in Figure 6:

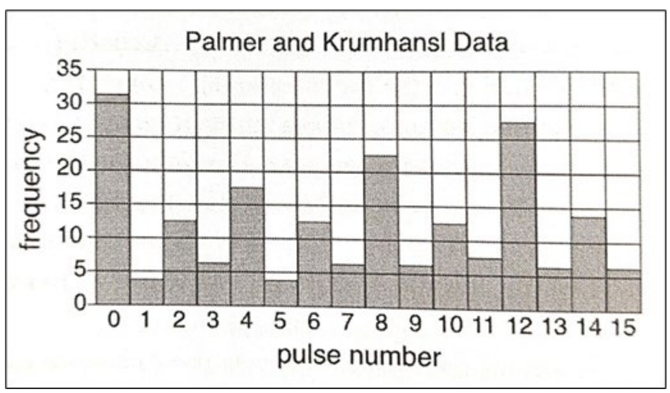

Figure 6 Common Practice music pulse saliency histogram

Once again, this histogram bears a striking resemblance to the GTTM hierarchy, save the exception that p12 is more frequent than p8. The final histogram of Western music that Toussaint offers is one compiled by Huron and Ommen of a select number of German folk songs. The graph is shown below in Figure 7:

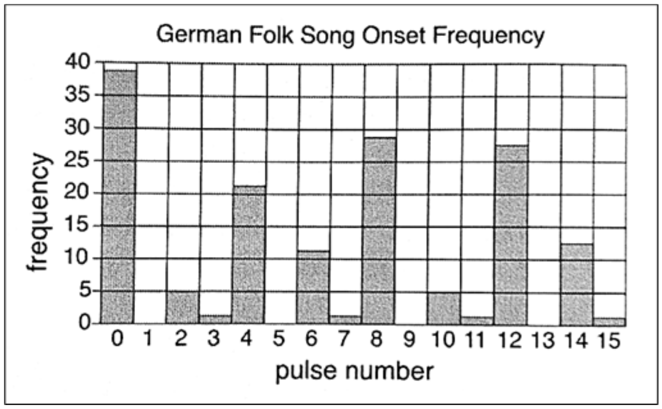

Figure 7 German folk song pulse saliency histogram

Once again, this graph very closely matches the priority hierarchy presented by the GTTM model. When Toussaint moves to his pulse saliency histogram for his selected African timelines, the results are quite different. The result is shown in Figure 8 below:

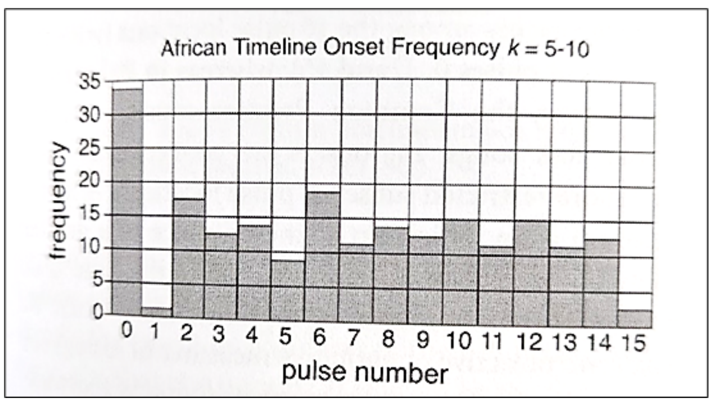

Figure 8 Afro-Diasporic timeline pulse saliency histogram

This graph doesn’t look like the other three histograms, or the GTTM hierarchy for that matter, at all. In fact, it seems that there is no apparent or stark pattern shown by these 34 timelines. However, Toussaint concludes that it still resembles a similar pattern to the GTTM hierarchy and Western music samples because it retains the “same perfectly alternating contour.” (Toussaint 2020: 109) In other words, all histograms so far contain the same oscillation in frequency values or priorities. If we use the symbols “+” for an increase in value, “-“ for a decrease in value, and

“0” for a maintenance of value, then, starting with p0 the contour for Figures 4-8 would all be [-+-+-+-+-+-+-+-+].

		Pulse Number															
ID	Rhythm Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Bossa-1	X			X			X				X			X		
2	Bossa-2	X			X			X			X			X			
3	Bossa-3	X			X			X			X				X		
4	Shiko	X				X		X				X		X			
5	Timini	X		X				X		X				X			
6	Kromanti	X		X				X				X		X			
7	Tuareg	X				X		X		X				X			
8	Tipitina	X		X		X					X					X	
9	Son	X			X			X				X		X			
10	Rumba	X			X				X			X		X			
11	Gahu	X			X			X				X				X	
12	Domba	X		X			X				X				X		
13	Kpatsa	X				X				X			X		X		
14	Rap-X	X				X			X		X			X			
15	Soukous	X			X			X				X	X				
16	Rap-2	X		X					X			X				X	
17	Mambo-1	X			X		X			X		X			X		
18	Mambo-2	X		X			X			X			X		X		
19	R-W-B	X		X			X			X			X			X	
20	Popcorn	X		X		X			X		X					X	
21	Funky	X		X		X			X		X			X			
22	Central-Africa	X		X		X		X		X			X			X	
23	Takoe	X			X		X			X		X		X		X	
24	Akom	X		X		X		X			X		X			X	
25	Adangme	X		X		X		X		X			X		X		
26	Samba	X		X			X		X		X			X		X	
27	Ghana	X		X		X		X			X		X		X		
28	Bembe-duple	X			X			X	X			X		X			X
29	Oyaa	X		X		X		X		X		X	X		X	X	
30	Ngbaka	X		X		X		X	X		X		X		X	X	
31	Ngbaka-Maibo	X		X		X		X	X		X		X		X		X
32	Kassa	X	X		X		X	X		X		X		X		X	
33	Mutuashi	X	X		X		X		X	X		X		X		X	
34	Rumba-palitos	X		X	X		X		X	X		X		X	X		X
	Histogram	34	2	18	13	14	9	19	11	13	12	15	11	15	12	13	3

Figure 9 Toussaint’s timeline dataset

A critical problem emerges, however, when we examine Toussaint’s dataset of 34 African timelines, shown in Figure 9. Although the collection initially appears coherent, a closer analysis with a clave-sensitive framework reveals a substantial flaw: nearly half of the timelines are oriented incorrectly. In other words, many of the patterns in Toussaint’s sample are effectively presented “backwards,” with their structural direction reversed relative to how they function in their originating traditions. This misorientation is not a minor or cosmetic error; it fundamentally alters the internal relationships between pulses and disrupts the very patterns whose metric properties Toussaint seeks to quantify. Because pulse saliency depends on aggregating vertically aligned onsets across multiple rhythms, any widespread reversal of direction produces misleading frequency distributions and, by extension, an inaccurate hierarchy of metric weight. Thus, before one can meaningfully interpret the resulting histogram, or draw conclusions about the nature of meter in African music, the underlying data must be correctly oriented. For visual aid, Figure 10 applies the hyperdimensional record-player analogy to Toussaint's dataset, marking the "red" and "blue" sides of each timeline to indicate their respective clave orientations.

		Pulse Number															
ID	Rhythm Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Bossa-1	X			X			X				X			X		
2	Bossa-2	X			X			X			X			X			
3	Bossa-3	X			X			X			X				X		
4	Shiko	X				X		X				X		X			
5	Timini	X		X				X		X				X			
6	Kromanti	X		X				X				X		X			
7	Tuareg	X				X		X		X				X			
8	Tipitina	X		X		X					X					X	
9	Son	X			X			X				X		X			
10	Rumba	X			X				X			X		X			
11	Gahu	X			X			X				X				X	
12	Domba	X		X			X				X				X		
13	Kpatsa	X				X				X			X		X		
14	Rap-X	X				X			X		X			X			
15	Soukous	X			X			X				X	X				
16	Rap-2	X		X					X			X				X	
17	Mambo-1	X			X		X			X		X			X		
18	Mambo-2	X		X			X			X			X		X		
19	R-W-B	X		X			X			X			X			X	
20	Popcorn	X		X		X			X		X					X	
21	Funky	X		X		X			X		X			X			
22	Central-Africa	X		X		X		X		X			X			X	
23	Takoe	X			X		X			X		X		X		X	
24	Akom	X		X		X		X			X		X			X	
25	Adangme	X		X		X		X		X			X		X		
26	Samba	X		X			X		X		X			X		X	
27	Ghana	X		X		X		X			X		X		X		
28	Bembe-duple	X			X			X	X			X		X			X
29	Oyaa	X		X		X		X		X		X	X		X	X	
30	Ngbaka	X		X		X		X	X		X		X		X	X	
31	Ngbaka-Maibo	X		X		X		X	X		X		X		X		X
32	Kassa	X	X		X		X	X		X		X		X		X	
33	Mutuashi	X	X		X		X		X	X		X		X		X	
34	Rumba-palitos	X		X	X		X		X	X		X		X	X		X
	Histogram	34	2	18	13	14	9	19	11	13	12	15	11	15	12	13	3

Figure 10 Toussaint's timeline dataset with directional labeling

This visualization makes clear not only which rhythms are reversed, but also how their misalignment disrupts the symmetry that should be preserved across the sample. By clearly indicating each timeline's directional halves in this way, the figure highlights the structural inconsistencies introduced by Toussaint's orientation choices and allows the reader to see immediately how the dataset fragments into two incompatible groups which cannot be meaningfully aggregated because their directional frameworks are not aligned. In some cases, the same rhythm is included multiple times, but in both orientations. Rhythms 17 and 18 are an example of this, as are rhythms 23 and 25.

The basic solution is quite simple: align the rhythms properly and create a new histogram. The following figure is the resulting histogram that I calculated once I fixed the directionality issue and expanded the data set to include more well-established Afro-Diasporic timelines, without duplicates.

	61	43	18	73	25	36	71	23	73	4	86	7	71	29	45	30
91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
65	0	0	0	1	0	0	1	0	1	0	1	0	1	0	0	0
52	1	0	0	1	0	0	1	0	1	0	1	0	1	0	0	0
39	1	1	0	1	0	0	1	0	1	0	1	0	1	0	1	0
33	1	1	0	1	0	1	1	0	1	0	1	0	1	0	1	0
26	1	1	0	1	0	1	1	0	1	0	1	0	1	1	1	1
13	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Figure 11 Corrected Afro-Diasporic timeline pulse saliency histogram

As shown in Figure 11, the corrected graph differs dramatically from the one presented in Figure 8. Whereas Toussaint's original histogram produced a largely ambiguous and internally inconsistent distribution, the corrected version reveals a pattern that is substantially more coherent and articulate. Once the rhythms are properly oriented, the aggregated onset frequencies no longer cancel or obscure one another; instead, a clear hierarchical contour emerges, with distinct peaks and troughs that reflect the structural priorities found across the traditions represented in the dataset. In other words, the correction transforms what previously appeared to be an inconclusive pattern into one that displays a meaningful and interpretable organization. As a side-observation, this histogram newly yields the contour [--+-++-+-+-+-+-+].

With this corrected histogram in place, each onset now has a clearly defined statistical prominence, reflecting how frequently it appears across correctly oriented timelines from the African Diaspora. These frequency derived priorities form the basis for assigning each pulse position a numerical weight, a value that captures its relative structural importance within the cycle. Once these weights are established, they can be utilized to accurately determine the directionality of any individual rhythm. In essence, this histogram provides the beginning of a stable statistical grammar, and the model articulated in the following section uses this grammar to determine whether a given rhythm aligns more correctly with the “3-2” direction or “2-3” direction, or if it’s ambiguous or clave-neutral. This is the “vertical tension” contour that Lehmann is referring to, the hierarchical prominence values, the weights “created for the short-range directionality of the clave/timeline period.” (Lehmann 2002: 71) What follows is an explanation of how these weights are calculated and employed to evaluate clave direction in a precise and reproducible way.

Chapter 4: A Methodological Framework for Evaluating Clave Orientation

In my corrected histogram, which I will refer to as the 16-pulse clave model, each pulse position is assigned a unique frequency value based on its percentage in the top row of Figure 11. These percentages indicate how often each onset position occurs across the entire sample of correctly oriented timelines: for example, p_4 appears in 25% of the sampled rhythms, whereas p_9 appears in only 4%. To convert these raw frequencies into analytically useful categories, the percentage values are grouped into seven priority tiers (1-8). The boundaries of these tiers are determined by the standard deviation of the frequency distribution, allowing pulses with similar statistical prominence to be grouped while still preserving meaningful distinctions between them. These bounds are further refined to ensure that no pair of corresponding pulses receives the same priority value, a necessary adjustment in cases such as the cáscara pulses p_5 and p_{13}, whose raw frequencies initially grouped them in the same tier. This procedure yields a set of uniquely weighted pulse positions suitable for evaluating the directional structure of any given rhythm.

The given frequency tier value of any pulse will be referred to as $f(p_k)$, where k is the pulse position. For example, $f(p_0) = 6$ and $f(p_{11}) = 1$. Each pulse within the 16-pulse cycle has an individual frequency tier value. The 16-pulse clave model can be shown as an array of these values, as shown below:

Pulse:	$f(p_0)$	$f(p_1)$	$f(p_2)$	$f(p_3)$	$f(p_4)$	$f(p_5)$	$f(p_6)$	$f(p_7)$	$f(p_8)$	$f(p_9)$	$f(p_{10})$	$f(p_{11})$	$f(p_{12})$	$f(p_{13})$	$f(p_{14})$	$f(p_{15})$
Tier Value:	6	5	2	7	2	4	7	2	7	1	8	1	7	3	5	8

Figure 12 Frequency tier values of the 16-pulse clave model

The weight of any pulse position p_k, denoted $w(p_k)$, is defined as the absolute difference between the frequency tier of that pulse and the frequency tier of its corresponding pulse in the opposite half of the cycle. Using the terminology established earlier, if we want the weight of the *quinto* (Q) pulse (either $p_1$or p_9), we compare the frequency tiers assigned to both positions; the resulting weight is simply the magnitude of the difference between them. In equation format:

$$w(p_k) = | f(p_k) \ - \ f(p_{k+8}) | , 0 \leq k \leq 7$$

where:

$f(p_k)$ is the frequency tier (priority value) of pulse p_k,

p_{k+8} is its corresponding pulse in the opposite half of the sixteen-pulse cycle.

This yields the table of weight values shown below:

Pulse:	**$w(p_0)$**	**$w(p_1)$**	**$w(p_2)$**	**$w(p_3)$**	**$w(p_4)$**	**$w(p_5)$**	**$w(p_6)$**	**$w(p_7)$**	**$w(p_8)$**	**$w(p_9)$**	**$w(p_{10})$**	**$w(p_{11})$**	**$w(p_{12})$**	**$w(p_{13})$**	**$w(p_{14})$**	**$w(p_{15})$**
Weight Value:	1	4	6	6	5	1	2	1	1	4	6	6	5	1	2	1

Figure 13 Weight values of the 16-pulse clave model

Because weight values are shared by corresponding pulses, the array of weights forms a mirrored distribution. In terms of determining clave direction, a weight value represents the degree to which the presence of that pulse influences the directional analysis of any given 16-pulse rhythm. According to this model, the pulses exerting the strongest influence are S and B, each with a weight of 6. They are followed by K with a weight of 5 and Q with a weight of 4. P contributes only a weight of 2, while F, C, and O exert the least directional influence, each with a weight of 1.

I previously noted that within any corresponding pulse pair, one pulse is designated *primary* and the other *secondary*, depending on which is more “clave-aligned” in its traditional context (Moore 2012: 81). In my model, this distinction is determined by comparing the frequency tier values assigned to each pulse: the pulse with the higher tier value is classified as primary. For example, the first-half quinto at p_1, denoted Q_1, has a higher frequency tier than its corresponding second-half quinto at p_9, denoted Q_2. Accordingly, Q_1 functions as the primary quinto, and Q_2 as the secondary quinto. Primary and secondary pulses will be marked using the following notation: $p^{pw}$and p^s, where w is $w(p_k)$. The resulting array of labeled pulses is shown below:

Pulse #	p_0	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}
Name	F_1^s	Q_1^{p4}	S_1^s	B_1^{p6}	K_1^s	C_1^{p1}	P_1^{p2}	O_1^s	F_2^{p1}	Q_2^s	S_2^{p6}	B_2^s	K_2^{p5}	C_2^s	P_2^s	O_2^{p1}

Figure 14 Pulses of the 16-pulse clave model with primary and secondary pulses labeled

This framework aligns perfectly with the categorizations proposed by both Moore and Peñalosa for the *quinto, bombo, ponche,* and *backbeat* pulses. At the same time, it extends their work by incorporating all remaining pulse positions and, through the use of weight values, organizing them into a comprehensive hierarchy of relative importance. It's important to note that both Moore and Peñalosa focus solely on the Cuban context, whereas the rhythms sampled for this model span the entire African diaspora. The resulting coherence is striking, indeed suggesting the presence of a deeper, unifying temporal grammar.

The very same process can be done with 12-pulse cycles, with some minor adjustments to the equations to account for the difference in cycle length. The results of my calculations with 12-pulse cycles are shown below. First are the frequency values:

Pulse:	**f(p_0)**	**f(p_1)**	**f(p_2)**	**f(p_3)**	**f(p_4)**	**f(p_5)**	**f(p_6)**	**f(p_7)**	**f(p_8)**	**f(p_9)**	**f(p_{10})**	**f(p_{11})**
Tier Value:	6	2	6	2	7	3	5	6	2	7	3	4

Figure 15 Frequency tier values of the 12-pulse clave model

Following are the weight values:

Pulse:	**w(p_0)**	**w(p_1)**	**w(p_2)**	**w(p_3)**	**w(p_4)**	**w(p_5)**	**w(p_6)**	**w(p_7)**	**w(p_8)**	**w(p_9)**	**w(p_{10})**	**w(p_{11})**
Weight Value:	1	4	4	5	4	1	1	4	4	5	4	1

Figure 16 Weight values of the 12-pulse clave model

Lastly are the labeled pulses:

Pulse #	p_0	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}
Name	F_1^{p1}	Q_1^s	B_1^{p4}	K_1^s	P_1^{p4}	O_1^s	F_2^s	Q_2^{p4}	B_2^s	K_2^{p5}	P_2^s	O_2^{p1}

Figure 17 Pulses of the 12-pulse clave model with primary and secondary pulses labeled

Here, I will outline the process for using this data and model to calculate the clave direction of any rhythm. For clarity, I will use the 16-pulse model, although the procedure is identical for the 12-pulse model. The first step is to define the rhythm in terms of its onsets, the pulses that are ‘played’ rather than rested. Each onset is then assigned its corresponding frequency tier value, and these values are summed to produce the first total, which I refer to as the ‘3–2 Value,’ following Cuban directional terminology.

Next, a second sum is calculated, simulating the rhythm as if it were oriented in the opposite direction. In this calculation, each pulse contributes the frequency value of its corresponding pulse on the opposite half of the cycle, for example, p_1 adds the value of p_9, and p_{12} adds the value of p_4. This total is referred to as the ‘2–3 Value.’ Comparing the two sums determines the rhythm’s directional orientation: the higher sum indicates the clave direction of the rhythm.

The magnitude of the difference between the sums quantifies the strength of this directional implication, with smaller differences signaling greater clave ambiguity, and larger differences indicating a clearer, more pronounced orientation. This method allows for a systematic and replicable way to assess rhythmic directionality, providing both a qualitative and quantitative measure of clave orientation and perhaps the unspoken intuitions that form it. Represented mathematically, the process looks like this:

$$o_k = \begin{cases} 1 & , if\ pulse\ k\ is\ an\ onset\ (played) \\ 0 & , if\ pulse\ k\ is\ a\ rest\ (silent) \end{cases}$$

$$Direction = \begin{cases} 3/2 & , \sum_{k=0}^{15} o_k \times f(p_k) > \sum_{k=0}^{15} o_k \times f(p_{(k+8)\ mod\ 16}) \\ 2/3 & , \sum_{k=0}^{15} o_k \times f(p_{(k+8)\ mod\ 16}) > \sum_{k=0}^{15} o_k \times f(p_k) \\ Neutral & , \sum_{k=0}^{15} o_k \times f(p_k) = \sum_{k=0}^{15} o_k \times f(p_{(k+8)\ mod\ 16}) \end{cases}$$

$$Strength = \left| \sum_{k=0}^{15} o_k \times f(p_k) - \sum_{k=0}^{15} o_k \times f(p_{(k+8)\ mod\ 16}) \right|$$

We can also see the process visually by looking at my 16-pulse clave model:

	61	43	18	73	25	36	71	23	73	4	86	7	71	29	45	30	
91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
78	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
65	0	0	0	1	0	0	1	0	1	0	1	0	1	0	0	0	
52	1	0	0	1	0	0	1	0	1	0	1	0	1	0	0	0	
39	1	1	0	1	0	0	1	0	1	0	1	0	1	0	1	0	
33	1	1	0	1	0	1	1	0	1	0	1	0	1	0	1	0	
26	1	1	0	1	0	1	1	0	1	0	1	0	1	1	1	1	
13	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Half	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	
Value	6	5	2	7	2	4	7	2	7	1	8	1	7	3	5	3	
Weight	1	4	6	6	5	1	2	1	1	4	6	6	5	1	2	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
INPUT:	x			x			x				x		x				
3-2 Value	6	0	0	7	0	0	7	0	0	0	8	0	7	0	0	0	**35**
2-3 Value	7	0	0	1	0	0	5	0	0	0	2	0	2	0	0	0	**17**
OUTPUT: 3-2 Strength: 18																	

Figure 18 16-pulse clave model with Cuban *son clave* in the 3-2 orientation

The analyzed rhythm is typed into the INPUT row, with an x marking an onset. The frequency values for each onset are shown in the "3-2 Value" row, and the opposite values for each onset are shown in the "2-3 Value" row, with each rows sum shown in the final column. The output for this particular rhythm, known as *son clave* in Cuba, is 3-2, meaning that it is currently aligned in the 3-2 orientation with respect to the model. Below is the input and output for a rhythm classified in the 2-3 direction:

Pulse	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
INPUT:	x		x			x		x		x			x		x		
3-2 Value	6	0	2	0	0	4	0	2	0	1	0	0	7	0	5	0	**27**
2-3 Value	7	0	8	0	0	3	0	3	0	5	0	0	2	0	7	0	**35**
OUTPUT: 2-3 Strength: 8																	

Figure 19 16-pulse clave model with a rhythm in the 2-3 orientation

Below is my 12-pulse clave model, calculated in the same exact way as my 16-pulse clave model:

	69	17	74	14	80	26	57	66	23	77	26	46	
102	0	0	0	0	0	0	0	0	0	0	0	0	
89	0	0	0	0	0	0	0	0	0	0	0	0	
76	0	0	0	0	1	0	0	0	0	1	0	0	
64	1	0	1	0	1	0	0	1	0	1	0	0	
51	1	0	1	0	1	0	1	1	0	1	0	0	
38	1	0	1	0	1	0	1	1	0	1	0	1	
25	1	0	1	0	1	1	1	1	0	1	1	1	
13	1	1	1	1	1	1	1	1	1	1	1	1	
0	1	1	1	1	1	1	1	1	1	1	1	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	
Half	0	1	2	3	4	5	0	1	2	3	4	5	
Value	6	2	6	2	7	3	5	6	2	7	3	4	
Weight	1	4	4	5	4	1	1	4	4	5	4	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	
INPUT:	x		x			x		x		x			
3-2 Values	6	0	6	0	0	3	0	6	0	7	0	0	**28**
2-3 Values	5	0	2	0	0	4	0	2	0	2	0	0	**15**
OUTPUT: 3-2 Strength: 13													

Figure 20 12-pulse clave model with a rhythm in the 3-2 orientation

This model for analyzing clave direction provides a robust and consistent framework for understanding rhythmic orientation across the African diaspora, reconciling empirical observation with encultured musical intuition. In the following section, I highlight two observations that suggest avenues for further research, approaches that could deepen this framework by examining not only statistical patterns, but also the emergent properties of the clave cycle itself.

Chapter 5: Observations for Future Research

In Vurkaç's conclusion, he mentions the existence of clave ambiguous patterns as an area for future research. (Vurkaç 2012: 60) Of course, this seems obvious at first. In fact, any cyclical rhythm with symmetric halves yields a neutral clave direction when run through my model. This is because the 2-3 and 3-2 summations end up being the same, because only corresponding pulses are chosen as onsets. An example is shown below, in a 16-pulse cycle.

Pulse	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
INPUT:	x			x			x		x			x			x		
3-2 Value	6	0	0	7	0	0	7	0	7	0	0	1	0	0	5	0	**33**
2-3 Value	7	0	0	1	0	0	5	0	6	0	0	7	0	0	7	0	**33**
OUTPUT: NEUTRAL Strength: 0																	

Figure 21 16-pulse clave model with symmetric clave neutral rhythm

What, then, about asymmetrical rhythms? This is the issue Vurkaç appears to gesture toward in his remarks. In practice, asymmetrical patterns tend to favor one clave orientation over the other, except in cases where the asymmetry falls exclusively on pulse positions with the lowest weight values. An example of this, in the 16-pulse clave model, is provided below:

Pulse	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
INPUT:	x		x		x			x	x		x		x	x			
3-2 Value	6	0	2	0	2	0	0	2	7	0	8	0	7	3	0	0	**37**
2-3 Value	7	0	8	0	7	0	0	3	6	0	2	0	2	4	0	0	**39**
OUTPUT: 2-3 Strength: 2																	

Figure 22 16-pulse clave model with asymmetrical clave neutral rhythm

Here, the asymmetry lies in p_7 and p_{13}. Pulses O and C, as we know from earlier, each have a weight value of 1, meaning that they have a relatively weak effect on the direction of the rhythm. It makes sense that the resulting analysis would be so close to 0, so close to neutral.

However, in a 12-pulse clave model, I managed to find a class of asymmetric rhythms who achieve a neutral or near neutral analysis without relying on low weight values. The following figure highlights one prime example:

Value	6	2	6	2	7	3	5	6	2	7	3	4	
Weight	1	4	4	5	4	1	1	4	4	5	4	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	
INPUT:	x	x	x		x	x	x		x	x	x		
3-2 Values	6	2	6	0	7	3	5	0	2	7	3	0	**41**
2-3 Values	5	6	2	0	3	4	6	0	6	2	7	0	**41**
OUTPUT: NEUTRAL Strength: 0													

Figure 23 12-pulse clave model with asymmetrical clave neutral rhythm

Twelve is not only divisible by two, but also by three. This rhythm, while not showing symmetry with regard to equal halves, shows symmetry with regard to equal thirds. Perhaps it is for this reason that it gives an output of neutral? This possibility seems far-fetched considering the fact that the model is calculating clave direction based on bisectional symmetry and not 'tri-sectional' symmetry, but it is highly unlikely that this is mere coincidence. Indeed, all other "tri-sectionally" symmetric rhythms yield either neutral or near neutral analyses. Below are two other examples:

Value	6	2	6	2	7	3	5	6	2	7	3	4	
Weight	1	4	4	5	4	1	1	4	4	5	4	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	
INPUT:		x				x				x			
3-2 Values	0	2	0	0	0	3	0	0	0	7	0	0	**12**
2-3 Values	0	6	0	0	0	4	0	0	0	2	0	0	**12**
OUTPUT: NEUTRAL Strength: 0													

Figure 24 12-pulse clave model with a second asymmetrical clave neutral rhythm

Value	6	2	6	2	7	3	5	6	2	7	3	4	
Weight	1	4	4	5	4	1	1	4	4	5	4	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	
INPUT:	x	x			x	x			x	x			
3-2 Values	6	2	0	0	7	3	0	0	2	7	0	0	**27**
2-3 Values	5	6	0	0	3	4	0	0	6	2	0	0	**26**
OUTPUT: 3-2 Strength: 1													

Figure 25 12-pulse clave model with a third asymmetrical clave neutral rhythm

This observation not only hints at a deeper structure merely implied by the statistical analysis, but it also holds up to how these rhythms are employed in traditional contexts, both as neutral timelines or neutral solo phrases, commonly played on either side of the clave. It may well be possible to generate various frequency arrays that consistently satisfy this property, but pursuing that task lies beyond the scope of this study and remains open for future research.

A second observation that I have encountered concerns the striking structural parallels between European scalar systems and Afro-Diasporic rhythmic practice. These two domains, often treated as conceptually separate, share underlying principles of asymmetry, hierarchy, and patterned tension and release, suggesting that they may be governed by similar generative logics. Peñalosa notes:

> It is worth noting that the African standard pattern and the European major scale both exhibit the same structural properties. If one pulse is considered the equivalent of a half-step and two pulses a whole step, the correspondence is evident… The correspondence of these two patterns is not mere coincidence. Both the rhythmic properties of Africa and the harmonic principle of Europe are based on simple whole number ratios whose workings were articulated by the Greek philosopher and mathematician Pythagoras. The two most important rhythmic ratios in African-based rhythm are 3:2 and 3:4. In European-based music the perfect 5th is generated by the harmonic ratio of 3:2 and the perfect 4th by 3:4. A.M. Jones's seemingly simplistic statement that "rhythm is to the African what harmony is to the European" takes on deeper meaning when one considers how both rhythm and harmony are generated by the phenomenon of proportional interactions. (Peñalosa 2012: 220)

The rhythm that Peñalosa refers to as the "African standard pattern" is shown below in my 12-pulse clave model: Notice how closely this rhythm matches the pattern of primary pulses in Figure 17. In fact, the only difference is the presence of p_5, which only has a weight value of 1.

Value	6	2	6	2	7	3	5	6	2	7	3	4	
Weight	1	4	4	5	4	1	1	4	4	5	4	1	
Pulse	0	1	2	3	4	5	6	7	8	9	10	11	
INPUT:	x		x		x	x		x		x		x	
3-2 Values	6	0	6	0	7	3	0	6	0	7	0	4	**39**
2-3 Values	5	0	2	0	3	4	0	2	0	2	0	3	**21**
OUTPUT: 3-2 Strength: 18													

Figure 26 12-pulse clave model with African 'standard pattern'

In general, structural symmetry between European harmony and African rhythm is not something that has gone unnoticed. In fact, Toussaint dedicates a whole chapter of his book to the phenomenon. (Toussaint 2020: 45) The observation that I offer here emerges from this conceptual premise and integrates it with a principle of harmonic theory encountered during my studies as a jazz major at the University of Oregon.

As a jazz major, I was trained to distinguish among the various modes of a diatonic scale and to understand how each is generated, both theoretically and in practice. In this context, a mode refers to a rotation of a scale: a reorientation in which a different pitch is treated as the root while the underlying sequence of whole steps and half steps remains unchanged. For example, the C-major (Ionian) scale is spelled C–D–E–F–G–A–B–C, and its intervallic structure can be represented numerically, using 1 to denote a half step and 2 to denote a whole step, as [2-2-1-2-2-2-1]. If we rotate this pattern so that the scale begins on D while preserving the same interval sequence, we obtain D–E–F–G–A–B–C–D, which corresponds to the Dorian mode and is expressed numerically as [2-1-2-2-2-1-2].

I was also trained to conceptualize the seven modes as forming a gradient ranging from "bright" to "dark" qualities. Although these descriptive terms are inherently somewhat subjective, they at least provide a useful framework for identifying the two poles of this modal spectrum. The "brightest" mode, Lydian, can be generated by stacking six perfect fifths above a chosen root pitch until seven distinct pitch classes are obtained, then compressing those pitches into a single octave. Conversely, the "darkest" mode, Locrian, is produced by stacking six perfect fourths above the root. Because a perfect fourth is the inversion of a perfect fifth, this procedure can equivalently be understood as stacking six perfect fifths below the root, in contrast to the upward stacking used to derive Lydian.

To obtain the next "brightest" mode beneath Lydian, one stacks five perfect fifths above the chosen root and one perfect fifth below it. This combination yields the Ionian mode, popularly known as the major scale. Progressing along the gradient toward increasingly "dark" modes simply involves successively relocating additional perfect fifths from above the root to positions below it, a process that continues until reaching Locrian, in which all six perfect fifths lie below the root.

Given the established relationship between the African Standard Pattern and the Ionian mode, I wondered whether a comparable pattern might emerge between this "brightness" gradient and the relative clave direction strengths of the corresponding rhythms. Even at first glance, the rhythms implied by the Lydian and Locrian modes I recognized as being diametrically opposed when it came to clave direction. This raised an intriguing question: might the other modes exhibit a similarly ordered relationship? If such a correspondence existed, it might suggest a deeper structural principle linking harmonic organization and rhythmic orientation. Below is a table that lays the modes out in order from "brightest" to "darkest," along with their numerical expression and clave alignment output as given by my 12-pulse clave model:

Mode Name	Fifths stacked above root	Fifths stacked below root	Numerical Representation	Clave Output
Lydian	6	0	2-2-2-1-2-2-1	3-2: 18 Strength
Ionian	5	1	2-2-1-2-2-2-1	3-2: 18 Strength
Mixolydian	4	2	2-2-1-2-2-1-2	3-2: 13 Strength
Dorian	3	3	2-1-2-2-2-1-2	3-2: 4 Strength
Aeolian	2	4	2-1-2-2-1-2-2	2-3: 5 Strength
Phrygian	1	5	1-2-2-2-1-2-2	2-3: 13 Strength
Locrian	0	6	1-2-2-1-2-2-2	2-3: 18 Strength

Figure 27 The seven diatonic modes along with their 12-pulse clave model analysis

Astoundingly, there does seem to be some sort of correlation between this ordering of modes, and the clave direction strength of each mode's rhythmic counterpart. The "brightest" modes have the highest strength in the 3-2 clave direction, and the "darkest" modes have the highest strength in the 2-3 clave direction. The modes between them appear to have clave direction strength values that consistently reflect their relative position in the "brightness" gradient.

This observation shows that there may indeed be a deeper connection between harmony and rhythm than previously thought, especially as it relates to the quantification of clave direction. Similar to my previous observation, it may very well be possible to reverse engineer this correlation to generate arrays of frequency values that satisfy the specified conditions, but likewise that task lies beyond the scope of this study and remains open for future research.

Chapter 6: Concluding Remarks

In this thesis I sought to develop a systematic cross-cultural framework for wide-sense clave, proposing that the rhythmic organizing principles most famously found in Cuban tradition are in fact only a single manifestation of a deeper concept shared across Afro-Diasporic musical traditions. In doing so, I addressed a gap in previous scholarship, correcting the errors in Toussaint's pulse saliency approach, expanding Peñalosa's and Moore's frameworks beyond Cuba, and offering a model whose consistency has been tested against an enormous amount of rhythmic material.

The resulting 12-pulse and 16-pulse clave models that I have offered provide a robust method for identifying primary and secondary pulses, determining rhythmic orientation, and understanding how rhythmic direction emerges from asymmetric contrast within a fixed cycle. These models have been validated against my experiences in learning Ewe, Ga, Akan, and Dagbani drumming, demonstrating that wide-sense clave is not limited to Cuban music, but manifests in shared structural patterns across the African Diaspora. Unlike Vurkaç's model, which treats all pulses as equally important, leading to inconsistencies and rhythmic disagreements with established tradition, my model recognizes an inherent multi-level priority hierarchy, leading to a consistent quantification of clave direction that also considers encultured musical intuition. Unlike Lehmann's model, which centers on only one selected rhythmic pattern, my model recognizes clave not as a single rhythm, but as a nuanced framework that can manifest itself strongly in many rhythmic forms.

Limitations do remain. The database of rhythms that I analyzed as a foundation for my model, while diverse and encompassing, is not exhaustive. The current model's statistical grounding is only a first step towards reverse engineering emergent musical properties. Future research might expand to developing models for other cycle lengths, such as 6, 8, 9, 18, or 24, using the same philosophy that frames my 12-pulse and 16-pulse models. Lehmann and Toussaint have done some good work on 24-pulse cycles that I want to dig into more in future research. Developing my publicly available online repository of rhythms and their clave mappings will make these concepts more accessible for a wider audience, which I anticipate will further discussion and research opportunities.

Ultimately, this research points to a unifying temporal grammar that underlies Afro-Diasporic music, connecting Cuba to Ghana and beyond. By revealing the structural logic embedded in these musical traditions, this thesis contributes to a deeper understanding of how clave operates across cultures, demonstrating that the intuition musicians often describe as "in the blood" can, in fact, be systematically described, analyzed, and shared. Wide sense clave is not only a conceptual tool, but also the key to understanding the rhythmic heartbeat that unites the African Diaspora.

Bibliography

Fiol, Orlando. "Hidden Rhythm: A Case For Clave As an Analytical Bridge Between West African Music and the West." 2007

Lehmann, Bertram. The Syntax of 'Clave' – Perception and Analysis of Meter in Cuban and African Music. Master’s thesis, Tufts University, 2002.

Moore, Kevin. Beyond Salsa Percussion Volume 1. Moore Music, 2012.

Moore, Kevin. Understanding Clave and Clave Changes. Moore Music, 2011.

Peñalosa, David. Rumba Quinto: Rhythmic Principles and Lead Drum Improvisation in Afro-Cuban Rumba. Bembe Books, 2010.

Peñalosa, David. The Clave Matrix: Afro-Cuban Rhythm: Its Principles and African Origins. Bembe Books, 2009.

Toussaint, Godfried T. The Geometry of Musical Rhythm: What Makes a "Good" Rhythm Good? 2nd ed., CRC Press, 2020.

Vurkaç, M. "A Cross-Cultural Grammar for Temporal Harmony in Afro-Latin Musics: Clave, Partido-Alto and Other Timelines." Current Musicology, 2013