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Ikorodo Music Analyzed Through Visualizations and Sonifications of Beat-Class Theory

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ABSTRACT

This paper explores how mathematical music theory (beat-class theory), represented through visualizations and sonifications using ski-hill (1) and cyclic graphs, provides a suitable approach for the analysis of the meter and rhythm of Ikorodo music of the Igbo people of Nigeria. Unlike traditional music theory, instruments of mathematical music theory have the capacity to represent the listener's psychoacoustic experience of music because modern meter theory (11) encompasses the recognition and documentation of the experience of mathematics during listening (4). Our presentation explains how the embodied psychoacoustic experience of both music and mathematics can be quantified and represented through visualizations and sonifications of beat-class theory when listening to Ikorodo music. Arguably, the use of traditional Western music theory in music textbooks to analyse all music has resulted in a 'dumbing down' of music curricula in general (2,3,4). However, recent research indicates the efficacy of teaching the isomorphic relation of mathematics and music in an interdisciplinary and student-centred approach (5,6,7). Thus, through the application of mathematics to analyse Ikorodo music we will demonstrate how the Igbo's Ikorodo music can be recognised for its complexity, beauty, unique characteristics, and cultural importance.

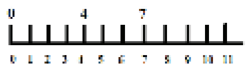
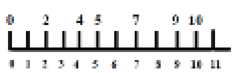
1. Introduction

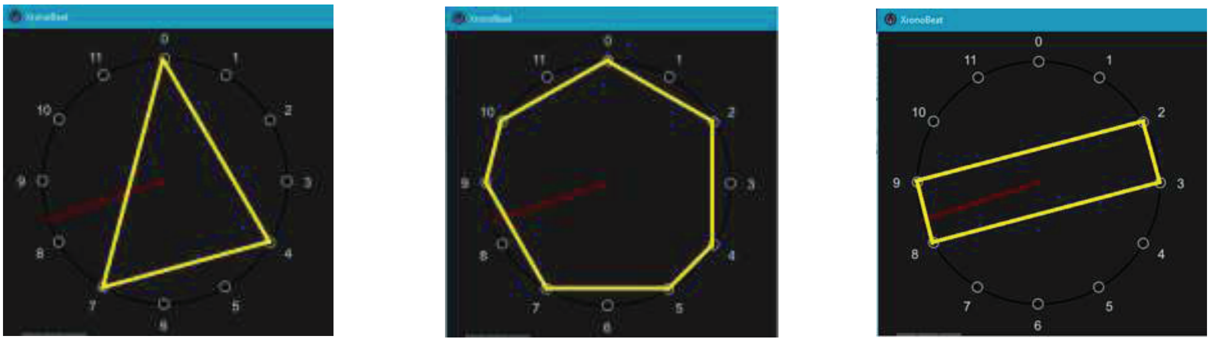
In the following section, we explore how the visualization and sonification of beat-class theory using ski-hill and cyclic graphs provides a suitable approach for the analysis of Ikorodo music of the Igbo people of Nigeria. With a focus on musical meter and rhythm our analysis demonstrates how mathematical music theory and the instruments of mathematical music theory the SkiHill app (8,9) and XronoBeat app (10) enable the listener to articulate their subjective embodied psychoacoustic experience of the Ikorodo music. Unlike traditional music theory, where notation-based understandings of meter propagate flawed understandings of meter (11,5,6), mathematical music theory (beat-class theory), possesses the qualities necessary to represent the quantification of music reported from listening to music.

2. Analysis of meter and rhythm

The following is an analysis of the meter and rhythm in the section approximately 1.05-1.35s of the Ikorodo music performed by the Ikorodo Cultural Group (Nsukka) sourced from YouTube. The tempo is around ♪.=120 beats per minute and the performance is approximately 3 minutes and 20 seconds in length. The beat-class cycle is C12, the pitch-class cycle is the chromatic collection C12, and the meters observed are <322> and <232>.

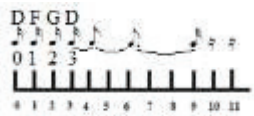
The Ikorodo music in the following analysis is performed by a mixed ensemble of vocalists and instrumentalists. A solo male vocalist is accompanied by nine instrumentalists including: four horns, two ichakas (shakers), okpokolo (woodblock), ogene (gong) and two drums. The Ikorodo performance is characterised by alternating sections between the solo male vocalist and the horns' polyphonic choruses. Repeated rhythmic motifs are performed by ichaka, okpokolo, ogene, and drums with occasional improvisation by the chorus vocalists and drums.

The Ikorodo performance begins (1.05s) on timepoint 7 of the C12 cycle with the okpokolo, ichaka, and ogene each providing a rhythmic drone. The onsets of the rhythms together form polymeter from three different divisions of the C12 cycle. The onsets of the okpokolo rhythm (subset of C12)  are illustrated as beat-class set theory on the following timeline as timepoints: , also as the bc-t set c=12, d=3 {0, 4, 7}, and represented on the cyclic graph XronoBeat a) of Figure 1. The okpokolo rhythm continues to repeat until 1.34s when the rhythm changes as the horns enter. The ichaka rhythm begins with an embellished form of the okpokolo rhythm with onsets on {0, 2, 4, 7, 9} and during the second full rotation of C12 the rhythm of the ichaka changes to {0, 2, 4, 7, 9, 10} with the onset of {10} performed by ichaka 2 at approximately 1.10s. Around 1.11s the onsets for the ichaka rhythm become  to include timepoint {5} performed by ichaka 2 in the b-ct set {0, 2, 4, 5, 7, 9, 10} illustrated as beat-class theory on a timeline  and represented on the cyclic graph b) in Figure 1. The ichakas repeat the same rhythm until 1.34s after the horns enter at 1.32s. The ogene rhythm  represented as timepoints  and the bc-t set c=12, d=4 {2, 3, 8, 9}repeats until 1.32s where there are additional onsets during the entry of the horns see Figure 1c). From 1.05s the drummers improvise quietly until adding a flourish at 1.29s as if to usher in the horns at 1.32s. Figure 1 illustrates the onsets for the rhythms of the okpokolo, ichaka and ogene represented as integers and polygons on C12 cycles through cyclic graphs:



a) b) c)

Figure 1 Percussion rhythms a) okpokolo c=12, d=3 (12,3) {0,4,7}; b) ichaka c=12,d=7 (12,7) {0, 2, 4, 5, 7, 9, 10}; and c) ogene c=12, d=4 (12,4) {2,3,8,9}

At 1.12s the solo vocalist (tenor) sings four notes beginning with a minor 3rd on the approximate pitches: D4 F4 G4 D4 represented on the following timeline as the set {0,1,2,3} 

. At 1.17s -1.25s around the range of F4 and A3 the singer's performance resembles recitative until returning to singing during the entry of the horns at 1.32s. At 1.32s a horn provides a drone on G3 while the melodies of the three harmonizing horns feature major thirds.

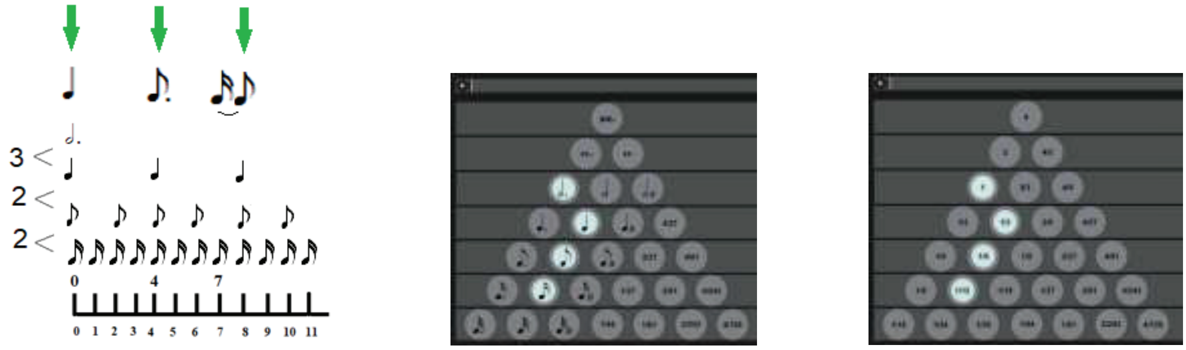
From listening to the opening of the Ikorodo music both minimal duple meter and minimal triple meter can be observed. Minimal duple meter, which can be represented as the ordered set notation <2> can be observed where the listener pairs two pulses in a ratio of 2:1, such as the two pulses mapped to the left direction on the ski-hill graph in Figure 2a). Minimal triple meter , or <3>, can be observed through pairing two pulses in a ratio of 3:1 mapped to the right direction such as represented in Figure 2b):

a) b)

Figure 2 a) minimal duple meter <2>; and b) minimal triple meter <3>

Deep meter occurs when the listener experiences two or more sets of minimal meters. Deep meter <322> can be observed from listening to the okpokolo rhythm in Figure 1a). This occurs because the third onset of the rhythm is metrically displaced ♪, as in a syncopation, and listeners can project and entrain to three evenly spaced onsets, for example, crotchets (Figure 3a) arrows). A listener who pairs the crotchet with a longer pulse, such as, the dotted minim forms a minimal triple meter; pairing the crotchet to a faster pulse, the quaver, forms a minimal duple meter; and pairing the quaver with a semiquaver forms a minimal duple meter. Figure 3a) illustrates the sets of minimal meters that form the deep meter <322> through a linear arrangement of vertically stacked pulses. The ski-hill graphs in Figures 3b) and 3c) enable the listener to quantify in a compact and efficient summary one of every pulse they hear from the metric hierarchy in both traditional notation, fractions, sonifications and polygons to articulate their experience of meter, mathematics and music.

Unlike other representations of meter the two different directions of the duple and triple metric pathways of the ski-hill graph and SkiHill app provide important visual and sonified distinctions see Figure 3b) and c):



a) b) c)

Figure 3 Deep meter <322> okpokolo a) vertical and linear pulse stacks; b) traditional notation mapped to the SkiHill app; c) fractions mapped to the SkiHill app

The okpokolo {0, 4, 7} rhythm is a subset of both the ichaka rhythm {0, 2, 4, 5, 7, 9, 10}and C12 because it shares both the timepoints of C12 and the onsets and the experience of meter <322> by the listener see Figure 4:

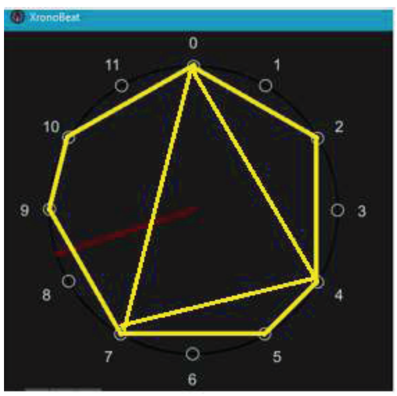
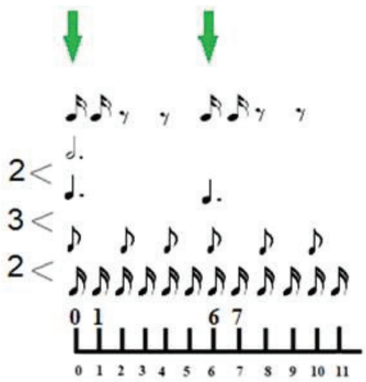


Figure 4 Ichaka {0, 2, 4, 5, 7, 9, 10}and okpokolo {0, 4, 7} rhythms represented on a cyclic graph

From listening to the ogene rhythm in Figure 1c) a new pulse, the dotted crotchet ♩. initiates a simple hemiola with the okpokolo's crotchet ♩ in a ratio of 3:2 to form direct metric dissonance between the deep meter <232> and the okpokolo meter <322>. The dotted crotchet occurs because of the quick succession of the pairs of semiquaver onsets {2,3} and {8,9} where the listener re-groups the quavers from sets of two's to sets of three's. The listener pairs the two inclusionally-related pulses ♪ and 𝅘𝅥𝅯 in a ratio of 2:1 in the imagination when there are no semiquaver onsets due to parallelism and the expectation that they will occur again (see Figure 5a)(12,13).The ogene rhythm, which began on timepoint 8, need only rotate $T^{-}2$ from {2} to {0} due to rotational equivalence: c=12, d=4 (12,4) {2,3,8,9} to {0,1,6,7}see Figure 5a) and b):

a) 

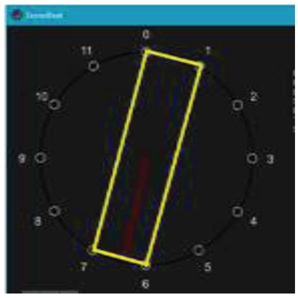
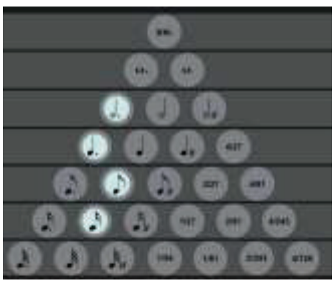
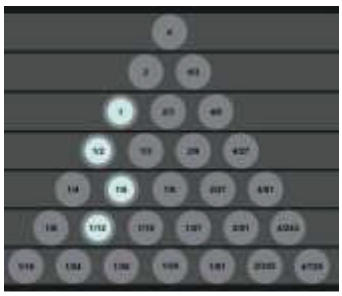
b) 

Figure 5a) Deep meter <232> for the ogene a) vertical and linear pulse stacks; b) $T^{-}2$ rotation of the ogene rhythm

The ski-hill graphs of Figures 6a) and b) represent the meter <232> in both traditional notation and fractions.





a) b)

Figure 6 Deep meter <232> for the ogene a) traditional notation mapped to the SkiHill app; b) fractions mapped to the SkiHill app

The ski-hill graph in Figure 7 represents the simple hemiola initiated by the presence of both a dotted crotchet and a crotchet:

Figure 7 Simple hemiola: meters <322> and <232>

The following is a summary of all of the divisions of C12 represented by beat-class theory discussed in the analysis:

C12	{0,	1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	11}:
12, 1	{0}											
12, 2	{0,						6}					
12, 3	{0}				4,				8}			
12, 6	{0,		2,		4,		6,		8,		10}	
12, 12	{0,	1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	11}

Figure 8 Beat-class theory representing divisions of C12

The following cyclic graph summarizes the divisions of C12 discussed in the Ikorodo analysis which can be observed from experience the meters <322> and <232>:

Figure 9 Cyclic graph XronoBeat representing the divisions of C12 for the meters <322> and <232>

3. Conclusion

As demonstrated, the visualizations and sonifications of beat-class theory through the ski-hill graph, SkiHill app and cyclic graphs such as XronoBeat to represent meter and rhythms, provide the listener with an opportunity to see and hear the mathematical underpinnings (sets) of the rhythms and meter they are experiencing to explain why a piece of music has a certain 'feel'. Cohn's mathematical music theory provide the universal language of mathematics through which the listener can articulate their quantified and embodied psychoacoustic experience of listening to music. Unlike traditional music theory, visualizations and sonifications of mathematical music theory (beat-class theory) has the capacity to examine music scientifically in order to reveal structures and details which would otherwise remain undiscovered. The value and potential for Cohn's mathematical music theory (beat-class theory) to preserve important details of cultural significance is immense. Introducing the narrative of mathematical music theory and visualizations of beat-class theory into music textbooks and pedagogical materials will not only raise the profile of music as a subject but it will also improve how the aural tradition of Igbo music is transmitted for future generations.

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